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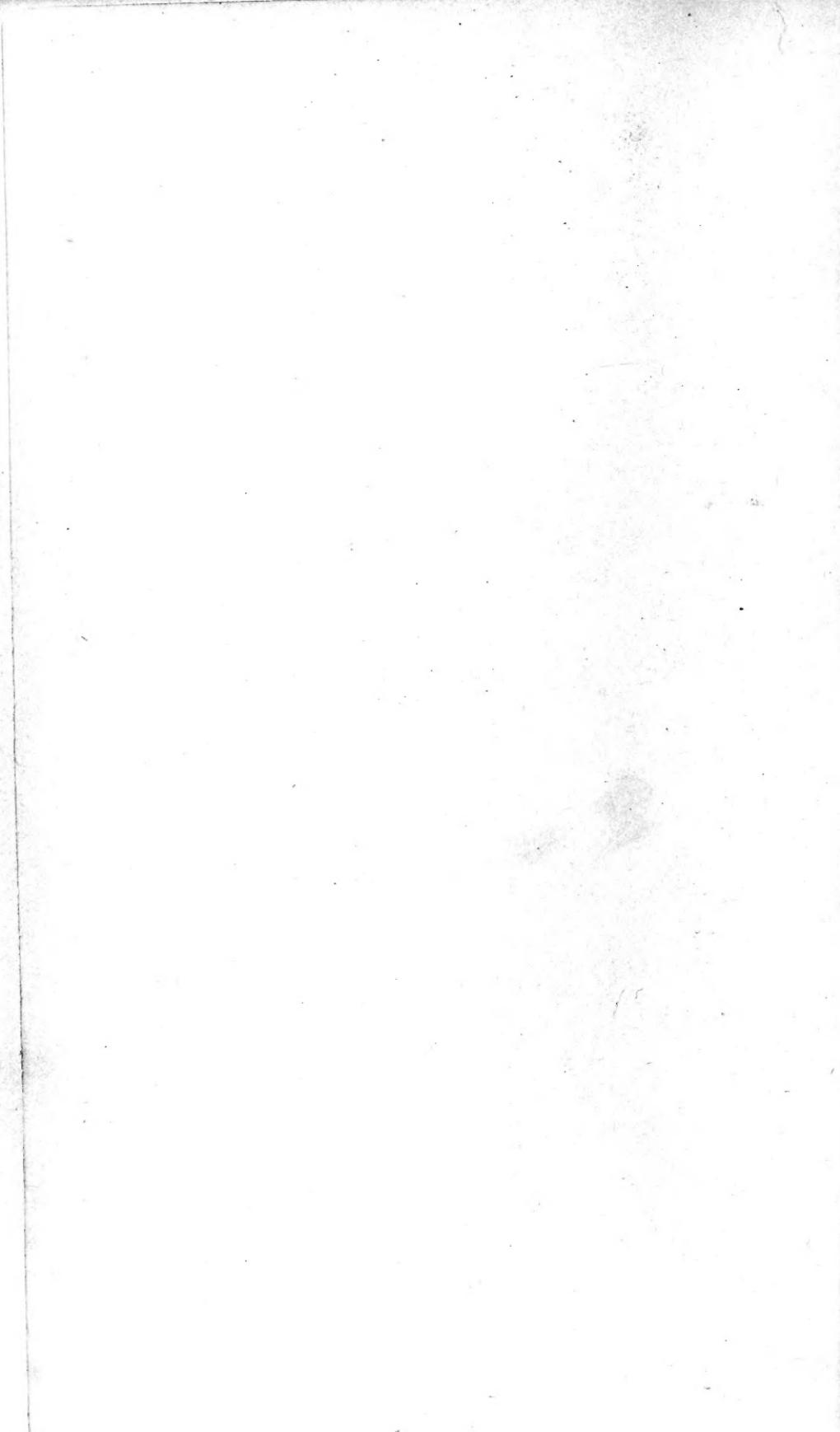
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AN INTRODUCTION
TO
PHARMACOGNOSY

BY

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Fully Illustrated
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PREFACE.

The following Introduction has been prepared with the hope that it may meet the needs of students of pharmacognosy in our schools of pharmacy.

In general scope it follows the well-established lines already laid down by our European confrères, departing in many particulars, however, from most works published heretofore in this country. Thus special emphasis has been laid on the microscopic rather than the macroscopic characters of drugs, although the latter have not been entirely neglected, and considerable attention has been given to the description of drug powders.

While there have been many manuals in which the student of plant structures could find ample instruction concerning general histological features, no work has been offered in this country which deals with the special individual anatomical characters of different drugs. Such works have been issued in Germany by Moeller, Tschirch, Meyer, Marmé, Flückiger, and others, and the monumental volume of Plancon and Collin, nearly two thousand pages, testifies in a measure to the value set by the French upon such studies. Greenish, of London, in 1903 gave to the English pharmacists a guide similar in general features to the volume here presented.

The present Introduction has been in preparation for some time, and here appears, not as a stupendous volume such as those of Flückiger or Plancon and Collin, but in a compressed and convenient form. This form, rather than that of an enormous reference book has been de-

liberately chosen as complying with what has been considered good pedagogic principles.

The drugs studied in detail have been carefully selected as those most typical of general drug structures, and it is believed that with the knowledge that may be thus acquired the student of pharmacognosy will be amply equipped to pursue individual research of an economically practical nature.

NEW YORK, *October, 1904.*

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INTRODUCTION TO PHARMACOGNOSY.

GENERAL INTRODUCTION.

Pharmacognosy is the study of drugs in their crude condition. It is one of the branches of Pharmacology, which in its broad sense consists of the study of remedial agents, or *Materia Medica*. Pharmacology includes Pharmacognosy, the study of drugs in their crude condition; Pharmacy, the preparation of drugs for the use of the medical practitioner; and Pharmacodynamics, the physiological action of drugs on living organisms. This latter branch is sometimes termed Pharmacology, but the word is then used in a narrow sense only.

Thus the study of Pharmacognosy would include the knowledge of drugs with reference to botany and chemistry, if of vegetable origin, or of their zoology and chemistry if derived from the animal kingdom. Substances derived by chemical manufacture, such as the simple salts, acids and alkalis, are not usually included in the study of Pharmacognosy. The substances usually coming within the domain of Pharmacognosy are of organic nature.

The study of plant drugs from the pharmacognostical standpoint would include the study of the habitat and general character of the plant from which the drug is derived, its place in the botanical system, the organ or

organs of the plant used, their gross and minute structure in the whole and powdered condition, and the chemistry of the constituents, especially of those which may be used in Therapeutics. Comprehensive treatments of this type have been carried out in such works as F. A. Flückiger, "Pharmakognosie des Pflanzenreiches;" A. Meyer, "Wissenschaftliche Drogenkunde;" Plancon et Collin, "Les drogues simples d'origine végétale," and other smaller manuals, such as those of Marmé, Moeller, Wigand, and Herail et Bonnet.

The subject-matter of Pharmacognosy may thus be divided into several fields. It may be considered mainly from the botanical point of view, constituting "Medical Botany;" it may be considered from the standpoint of the anatomist, "Histological or Anatomical Pharmacognosy," "Applied Plant Anatomy," or the entire interest of the study may be directed toward the investigation of the constituents, active and non-active, of the plant, in which case the study may be termed "Pharmaceutical Chemistry," meaning by this not the chemistry of pharmaceutic manufacture, but the chemistry of plant analysis, as outlined by Dragendorff and others. Finally there is a commercial side to the study of Pharmacognosy, which has to do with the methods of gathering, transporting, packing and selling of remedial agents. This has been termed "Commercial Pharmacognosy."*

The study of Pharmacognosy as a separate branch did not begin until about the year 1825, when Martius began to give his series of lectures at the University of Erlangen. Even at the present time it is evident that Pharmacognosy is not a branch of science with well-defined limitations. It overlaps so many fields of inquiry and is a

* See Essay by Tschirch of Berne in the *Pharmaceutische Zeitung*, 1881, No. 8, for a full discussion of the aims of modern Pharmacognosy. See also Flückiger, "The Principles of Pharmacognosy," translated by Powers.

compound of so much that, like many another group of sciences, it is a science for convenience' sake only.*

CLASSIFICATION OF ORGANIC DRUGS.

I. Animal Drugs.

II. Vegetable Drugs without Organic Structure.

Sugars, gums, gum resins, resins, oleoresins, balsams, volatile oils, milky juices, extracts and enzymes.

III. Vegetable Drugs with Organic Structure.

(a) Starches. (b) Simple Powders. (c) Galls. (d)

Plant Organs or parts of Organs. Roots, Rhizomes, Tubers, Bulbs, Corms, Wood and Stems, Barks, Leaves, Flowers and Floral Appendages, Fruits and Seeds.

The above very brief classification is offered as the one to be followed in the accompanying pages.

In the discussion of plant organs, or parts of organs, certain advantages might be derived from a study of the simple organs first, such as seeds and fruits, taking up later the organs with more complex anatomical structure, yet custom has more or less stamped its approval upon the reverse order of study, and it is here followed for the sake of convenience.

* See Flückiger, "Pharmakographia," for full discussion of the history of drugs and their method of preparation.

ANIMAL DRUGS.

As the science of medicine has progressed step by step, the great number of drugs derived from the members of the animal kingdom has been reduced. This large number of drugs was gradually introduced during the middle ages, so that in the middle of the sixteenth century at least 150 drugs derived from some portion of an animal were in constant use.

In the days of Hippocrates II, 400 B. C., and Dioscorides, 50 A. D., very few such drugs were employed, and at the present time the number is very small, except in the homeopathic Pharmacopœia, where many of the materials in use during the middle ages have been retained.

Certain animal drugs have maintained their reputation for efficiency, and only a few of these will be considered.

HIRUDO. THE LEECH.

This is a worm of the Annelid or Ringed-worm class. The most familiar one of the class is the *Hirudo medicinalis*, and this is the variety most commonly used. It lives in ponds and slow-flowing streams, where it feeds upon the blood of fishes, frogs, snails and other available food materials. It is its habit to take as much at one time as possible, gorging itself upon what supply of food is obtainable. It can thus often live a whole year without feeding twice. Its mode of locomotion is by means of the alternate use of the front and rear suckers, and when disturbed it swims by a rapid wave-like motion of the entire body.

Description.—The leech usually measures from 5 to 15 centimeters (2 to 6 inches) in length and is either

cylindrical or flattened, varying according to the state of contraction. The body is dark (blackish or grayish with brownish stripes). It is marked by a series of rings, at least 100 in number. The dorsal surface is mottled by distinct rows of spots, whereas the ventral surface is irregularly mottled. At both ends of the body the worm is provided with a mouthpiece or sucker.

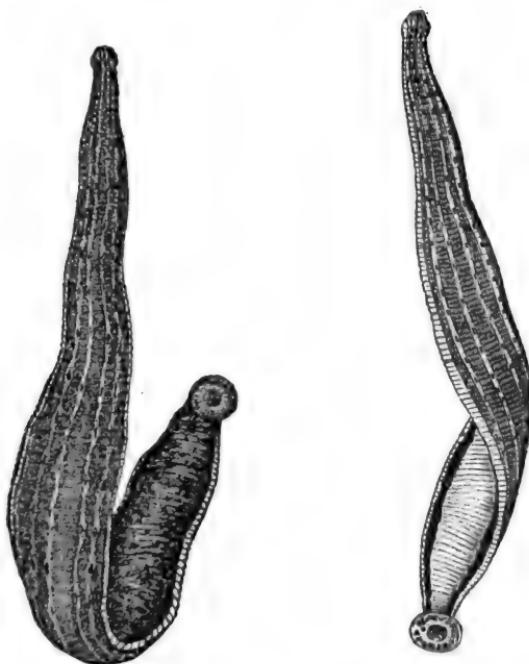


FIG. 1.—LEECH (Moeller).

With the posterior one the animal fastens himself, and then brings the triangular mouthpiece into play. This is provided with three sets of tooth plates, which by their muscular attachments move like a segment of a circular saw and make a triangular cut into the skin, through which the animal sucks the blood by means of its muscular pharynx. The clotting of the blood is prevented by a locally secreted ferment. The blood passes into a large

alimentary canal which is provided with a number of side pockets, all pointing forward. Fresh leeches are recognized by their fresh color, their active, elastic movements, and the fact that they do not give up any blood when salt or vinegar is dropped upon the mouth.

Fresh worms are preferable to those from which the blood has been squeezed, for although the latter will suck blood, they, as a rule, do so less lustily.

The leeches most commonly employed are: the Gray Leech (*Hirudo medicinalis*, L.), olivaceous in color, with six reddish longitudinal bands along the back, abdomen spotted with black and showing a blackish line on each side. Its rings are slightly roughened. It inhabits Europe, principally France, Germany, and Hungary. Green Leech (*Hirudo officinalis*, Moq.), greenish, with six dorsal bands similar to those of the former, olivaceous and unspotted abdomen, bordered by a black line. Its rings are very fine. The green leech is found with the gray leech. Dragon Leech (*Hirudo troctina*, Moq.), bright green on the back, with orange borders; isolated black macules bordered with orange take the place of the longitudinal bands. The abdomen is yellowish green and may or may not be spotted. This leech is an inhabitant of northern Africa.

There are a number of native species in the United States.

Collection and Preservation.—The leeches are caught in nets and are best preserved in clear water, at a temperature of from 10° to 20° C. (50° to 70° F.). The vessel should be comparatively large and should contain some stones and an oxygen-giving plant.

Uses.—To relieve congestion and abstract blood locally.

CANTHARIS. CANTHARIDES. SPANISH FLIES.

These are the dried bodies of a species of beetle, *Cantharis vesicatoria*, L., a member of the *Meloidæ* or Blister-

ing Beetle family. The group contains a large number of blistering beetles, many of which are coming into use.

In Europe, which is its native habitat, the Spanish fly lives upon plants of the olive family, more particularly on the ash, olive, lilac and privet, and upon the honeysuckle and elder. From these, in the early morning, they are shaken into cloths and killed by the vapor of chloroform, benzine, or other volatile liquid. They are then spread out in the sun and dried.

Description.—*Cantharis* varies from 15 to 30 mm. ($\frac{3}{5}$ to $1\frac{1}{2}$ inches) in length and 6 to 8 mm. ($\frac{1}{4}$ to $\frac{1}{2}$ inch) in breadth. It is of a brownish cast with coppery green iridescence. The head is somewhat transverse-heart-shaped, the antennæ are somewhat thickened, the outer joints being round or oval; the front foot has five joints, the hinder four. The wings are striated and have two or three fine longitudinal stripes or ribs. The smell is peculiar and unpleasant and the taste sharp and burning.

Chemistry.—The active principle has been isolated in the form of a crystallizable body, the anhydride of cantharidic acid, *Cantharidin*, $C_{11}H_{12}O_4$, and is found in a number of other beetles of allied genera, *Lytta*, *Meloë*, *Mylabris*, *Sitaris*, and *Zonaris*, and even the common Colorado potato beetle, *Doryphora*, 0.5 per cent. It is with difficulty soluble in water, slightly soluble in alcohol, ether, benzol, CS_2 , whereas in acetone, chloroform, acetic ether, and fatty and ethereal oils it is freely soluble. *Cantharidin* may be reduced by xylol. Other constituents are fat, 12 per cent., ash, 6.8 per cent.

Adulterations.—Other beetles with which Spanish flies are often mixed can be detected if the size and description given are carefully followed. Those most often used are:



FIG. 2.—CANTHARIS (Moeller).

Carabus auratus, L.; shorter, greenish above, legs and antennæ reddish.

Catonia aurata, L.; greenish above, below hairy, with a cross white line on the wings. Shorter and broader than the Spanish fly.

Cicambyx moschata, L.; about the same length but narrower, with very long (at least an inch) antennæ and a steel blue color.

Mylabris cichorii and *Mylabris phalerata*, Chinese flies, and other blistering beetles from the United States are being introduced, and a number of the American species have been found to contain more cantharidin than the European species. Flückiger found as high as 2.5 per cent. in the Brazilian species, *Epicauta adspersa*.

Physiological Action.—Cantharides is a violent irritant, producing when applied to the skin redness, smarting, and blisters. Sloughing may result from its application. Internally it is absorbed and is a violent poison with vomiting, purging, violent abdominal pain and collapse. It is eliminated mainly through the urine, and may induce violent symptoms in the genito-urinary tract. Poisoning is best treated by washing out the stomach, and the application of demulcents, mucilages, starch, cocaine, and morphine for pain. Intestinal antiseptics, salol, and bismuth for after-treatment of ulceration. Oils and fats should be avoided internally in the treatment of cantharides poisoning because of solubility of cantharidin in these menstrua. Dose, 0.005 to 0.06 gm. ($\frac{1}{10}$ to 1 grain) well diluted, in tincture.

VEGETABLE DRUGS WITHOUT ORGANIC STRUCTURE.

SUGARS AND SWEET EXUDATES.

MANNA.

Manna is the concrete saccharine exudation of *Fraxinus Ornus*, L. (nat. ord. Oleaceæ).

Fraxinus Ornus is distributed throughout eastern tropical countries and is cultivated to a great extent in more northern regions. The manna is obtained in many places from cultivated trees. These begin to produce after five years and continue to yield manna for twenty years, after which they are cut down and new ones planted. In August or September the trees are tapped for the sugar, by means of sharp knives, the cut usually being three or four inches long, and extending well through the bark into the wood. From this wound comes the sap, at first brownish and somewhat bitter, afterward white and sweet. It is collected as it drops out in receptacles varying with the place of culture.

Description.—Two main kinds occur in the market, stem manna and lump manna, Tears and Sorts, although a number of terms have been in use in different sections. Flake manna is commonly sold.

Stem or Tear Manna is produced by slow exudation and drying, whereby the manna forms in irregularly triangular pieces. When good samples are obtained the pieces are from 15 to 20 cm. (5 to 8 inches) long and 2 cm. ($\frac{1}{2}$ inch) thick. They have a porous crystalline appearance, are light brown in color, whiter on the surface.

Irregular and brownish pieces, collected later in the year, in which tears may be found, constitute the variety of *sorts*. Often the manna spreads out on the branches and is gathered as flattened pieces, *flakes*, which vary widely in size. *Fat* manna is a type of sort manna which is collected late in the year after finer varieties have been utilized. It is darker in color, softer and hygroscopic. It may contain some tears. It is liable to ferment rapidly and break down into a soft, fatty and bitter mass.

Chemistry.—Mannite, $C_6H_8(OH)_6$, 25 to 80 per cent.; also other sugars, grape sugar, invert sugar, mucilage, dextrin. Fraxin, $C_{16}H_{18}O_{10}$, is stated by Flückiger to be absent in old manna. Bitter principle, citric acid. Mannite, obtained by crystallization from alcohol, occurs in white rhombic prisms, is soluble in 6.5 parts of water (16° C.), melts at 165° C., without change, and can be sublimed. Manna does not reduce Fehling's solution. Mannite is widely distributed in the plant kingdom.

Other mannas are obtained from a variety of sources. *Tamarisk Gallica*, by stinging of an insect. *Coccus mannipanis*, exudes a clear white manna which is supposed to be the manna eaten by the Hebrews in the wanderings in the desert. *Lecanora esculenta*, a lichen, also enjoys a similar reputation. *Quercus vallonea* and *Persica*, *Alhagi Maurorum*, *Astragalus adscendens*, *Salix fragilis* and a variety of other plants contain manna.

Uses.—Demulcent, laxative, and as a food. Dose, q. s. to 30 gm. (1 oz.) in solution.

SACCHARUM. SUGAR. CANE SUGAR.

The refined sugar obtained from *Saccharum officinarum*, L., and from various species or varieties of *Sorghum* (nat. ord. Gramineæ) and also from one or more varieties of *Beta vulgaris*, L. (nat. ord. Chenopodiaceæ). Formula $C_{12}H_{22}O_{11}$.

The species of *Saccharum* and of *Sorghum* are from

tropical countries and are extensively cultivated in warm climates. The beet may be cultivated in northern temperate zones as well as in the tropics. Sugar-cane contains about 18 per cent. of sugar; beets, about 14 per cent. The general output of beet sugar is nearly twice that of cane sugar; over six million tons of the former were manufactured in 1900. Cane sugar is present in the sugar maple, carrot, turnip, and in most fresh fruits, in which latter it is usually inverted.

Description.—White, dry, hard, crystalline, granules, odorless, with a purely sweet taste. Permanent in the air. Soluble in half its weight of water; sparingly soluble in strong alcohol, insoluble in ether, chloroform, or carbon disulphide; fusible at 160° C. (320° F.); at temperature of 200° C. (392° F.) it is converted into *caramel*. Aqueous solutions are neutral to litmus paper. When acted on by bacteria and molds, or boiled with dilute acids, it is converted into *invert* sugar.

Uses.—Demulcent. Food.

SACCHARUM UVEUM. GLUCOSE. GRAPE SUGAR.

Grape sugar is a normal constituent of the juice of grapes, but is manufactured on a large scale from various starches, corn-starch in particular, by the action of weak acids. Formula, $C_6H_{12}O_6$, H_2O .

It occurs in whitish to yellowish masses, softer than cane sugar and hygroscopic. It crystallizes with or without water and is very soluble. One part of cold soluble in all proportions of hot water. It is about one-half as sweet as cane sugar. It is sparingly soluble in alcohol, insoluble in ether, and readily ferments with the production of alcohol. Solutions of grape sugar reduce Fehling's solution. Heating yields *caramel*.

Uses.—Much as cane sugar, but less often employed.

SACCHARUM LACTIS. LACTOSE. MILK SUGAR.

A peculiar crystalline sugar, obtained from the whey of cow's milk by evaporation, and purified by recrystallization. Formula, $C_{12}H_{22}O_{11}$, H_2O .

White, hard, crystalline masses, four-sided, yielding a white, gritty powder, odorless and with a slightly sweet taste. Permanent in the air. Soluble in six parts of cold water, and in one part of boiling water. Insoluble in alcohol, in ether, or in chloroform. It gives up its water of crystallization at 130° C. (266° F.) and melts at 204° C. (398° F.). On boiling with dilute acid it splits into dextrose and galactose. Caramel can also be obtained from milk sugar. It reduces Fehling's solution slowly.

Uses.—Chiefly as vehicle and for infants' feeding.

MEL. HONEY.

A saccharine secretion deposited in the honeycomb of the bee, *Apis mellifica*, L. (Insecta).

Honey is a syrupy liquid of a light yellow to pale yellowish-brown color, translucent when fresh, but gradually becoming opaque and crystalline. It has an aromatic odor and a cloying sweet taste. Honey is faintly acid to litmus paper. Specific gravity, 138 to 140.

Honey consists of a mixture of glucose and levulose, a little wax, mucilage, proteids, volatile oil, coloring-matter, and slight ash. Microscopically it contains fragments of portions of insect bodies and pollen grains. It is widely manufactured from glucose. The manufactured product, unless mixed with the native product, contains no traces of insect fragments and no pollen grains.

Uses.—Honey has a wide use as a food and as a demulcent. It makes an excellent vehicle for administering medicines to children. It is mildly laxative.

GUMS AND MUCILAGES.

In the gradual anabolism of plants there are built up numbers of bodies that are very closely allied one to another, and which are intimately related to the carbohydrates. Among these carbohydrates are some characterized by their relatively easy solubility in water and showing certain definite chemical reactions, notably the reaction toward saturated aqueous solutions of potassium acetate. The precise method of the histological formation of gums is still a matter of a great deal of controversy.*

Practically all the varieties of gum are characterized by their insolubility in alcohol, ether, or chloroform; and when heated with dilute sulphuric acid they are converted, for the most part, into simple sugars, glucoses, of the pentose ($C_5H_{10}O_5$) and hexose ($C_6H_{12}O_6$) groups.

In form they are not identical, but are usually roundish to elongated or rootlike or in tears, and only in rare instances have they characteristic shapes. Most gums show surface cracking; for instance, acacia. They usually have a sharp fracture when dry. In color they vary from white through various shades of yellow to brown. They are mostly translucent or transparent, some of the darker varieties being opaque; they have for the most part a glassy surface, at least in the broken surface. They are odorless, usually mucilaginous, sweetish or bitterish to taste. Many are markedly hygroscopic and tenacious, thus rendering it difficult to powder them.

They vary very widely as to their solubility—all will dissolve somewhat—when placed in water; some are readily soluble, others insoluble. Most gums possess the interesting property of being soluble in concentrated aqueous solution of chloral hydrate.

* Tschirch: Ueber die Entwicklungsgeschichte einiger Secret-behalter und die Genesis ihrer Secrete. Ber. d. Deut. bot. Gesellsch., 1888, S. 2.

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Watery solutions of the gums have a slight acid reaction; in many instances this is reinforced by the sulphuric acid which is frequently used to clean them.

Chemically the gums are very complex. They contain also many included substances, such as inorganic salts, tannin, sugars, coloring-matters and various proteids. The salts are usually compounds of potassium, calcium, or magnesium as carbonates, sometimes with oxalic acid. The presence of the sugars is usually indicated by the power of reducing copper. Of the chemical composition of the coloring-matters very little is known. The nitrogenous bodies are in part ferments, which are widely distributed in gums, and have had important functions in the metabolism of the plant.

Regarding the true gum substances, there is one group the members of which are soluble in water. These have heretofore been classified under the general title of the *arabins*. It would appear from most recent researches that these arabins are not simple bodies, but consist of mixtures of closely related compounds. Wiesner and Zeisel have recently proposed the name glycosido-gummic acids to include the group.*

A second group of gums is characterized by its comparative insolubility in water; these contain substances which have been named *cerasin* and *bassorin*. *Cerasin* is a colorless substance insoluble in water or alcohol. Its chemical and physical composition, when freed from the inorganic substances usually incorporated within it, shows great similarity to an insoluble variety of *arabin*, which is formed when arabin is heated to dryness and is termed *meta-arabic acid*. *Cerasin* acted on by enzymes, acting on one type of gum alone, is said to be converted into *arabin*.† It is perhaps better to regard *cerasin* as a type

* Die Rohstoffe des Pflanzenreiches, 2d edit., 1900, p. 61.

† Garros: Bull. Societe Chimique.

of substances, rather than as a single body of definite chemical composition.

Bassorin, like cerasin, is probably best described by referring to "the bassorins." They are colorless bodies, very slightly soluble in water. They contain few or no organic compounds.

Neither cerasin nor bassorin reduce Fehling's solution, and they both yield arabinose and galactose by hydrolysis. Both bodies are closely related to the plant mucilages and pectin bodies.

The method of the origin of gums in plants has been the subject of much diversity in opinion. While formerly they were held to be secretions, they are now regarded, for the most part, as chemical modifications of the tissues. Traces of tissue structure sometimes persist in slight degree in some—tragacanth, for example. All or any of the tissues, normal or pathological, may be affected by this metamorphosis of the cell walls. In all probability the metamorphosis is brought about by the action of the ferments, and Wiesner* in 1885 isolated a diastatic ferment which he thought caused the formation of gums.

Gums occur as the commonest plant products. While any tissue may be converted into gum, those of the organs of the periphery are more liable to undergo the metamorphosis.

In general the various commercial gums may be classed, following Wiesner, as follows, the words arabin, cerasin, and bassorin being taken in the broad sense already outlined.

(1) Arabin gums: Those rich in the arabin. Cerasin and bassorin are not present, or in very slight quantities. Here belong the bitter varieties of *Acacia*, *Feronia* and *Anacardium* gums.

(2) Cerasin gums: Those rich in cerasin and containing arabin as well. The gums of the *Prunus* type are here

* *Sitzungb. d. k. Akad. der Wiss. in Wien*, 1885.

included. These are: Peach, Cherry, Plum, Prune, Apricot, and Mandel gums.

(3) Bassorin gums: These consist mainly of bassorin with some gum allied to arabin. These are Tragacanth, Kuter, Bassora, Cocos, Chagnal, and Moringa gums.

(4) Bassorin and Cerasin gums: Mixture of these two gums. Gum of *Cochlospermum gossypium*.

THE ACACIA GUMS.

The acacia gums are the Arabian, Senegal, Cape, North, East and West African, and East Indian varieties. The acacias form a family, as it were, of gums, many of which vary widely the one from the other. The discussion of the different species which yield the numerous varieties is beyond the scope of the present work.* The United States Pharmacopœia recognizes the following:

ACACIA. GUM ARABIC.

A gummy exudation from *Acacia Senegal*, Willd. In roundish tears of various sizes, or broken into angular fragments, with a glass-like, sometimes iridescent fracture, opaque with numerous fissures, but transparent and nearly colorless in thin pieces, nearly inodorous, taste insipid, mucilaginous; insoluble in alcohol, but soluble in water, forming a thick, mucilaginous liquid.

Acacia Senegal is a native of Egypt rather than of Arabia, growing in the fertile valleys of the Nile and of Senegambia. Probably it is spread well into Central Africa. In and about the same regions there are a large number of species of *Acacia*, most of which yield gums. In the main, however, most of the gums of commerce are derived from *A. Senegal*.

The gum is obtained from plants eight to forty years

* G. Vée: *Etude sur les gommes dites arabiques.* Thèse Ecole de Pharmacie de Paris, 1888.

old from natural ruptures in the bark, and is gathered during or after the time of blossoming, January to April. The richness of the exudation depends in large part on the climatic conditions.

The gum coming from Kordovan from *A. Senegal* (*A. Verek*, Guill. et Perott.) is held to be the best in quality, and is collected in round nut-like pieces, or irregular angular ones, which are transparent and white, or have the slightest tinge of brown. It is easily broken with a glassy fracture and shows numerous cracks, most of which are superficial. Khartoum gum resembles this closely.

The West African gum from Senegal, mainly derived from *A. Senegal* (*A. Verek*, of French writers), comes in pieces egg-shaped, elongated oval or worm-shaped, about two inches long and perhaps one-third of an inch in thickness. There is, however, a great variation in the matter of size and shape. The color is more yellowish, or even more reddish, than that of the East African sorts, and the gum is more regular in surface, showing fewer cracks. Smaller pieces are similar to those from East Africa.

Cape gum occurs in still smaller fragments, resembling mastiche or sandarac. It is clear brown in color and is often mixed with impurities. Australian and Brazilian gums are of recent introduction.

The powder of gum arabic is odorless, taste sweetish and mucilaginous.

In commerce the pieces are sorted, often irrespective of origin, and made into different grades with corresponding prices, first, second, third, and fourth sifted sorts.

Chemistry.—The general chemistry of gum acacia has been considered. The specific gravity varies from 1.50 to 1.60. They are completely soluble in water and give a thick mucilage, slightly acid in reaction.

Microscopical.—Little can be made of gum arabic under

the microscope. A few cell walls, occasionally some fragments of detached corky tissues, and some crystals. In adulterated powdered gum arabic the microscopic pictures will naturally vary according to the adulterant. Various flours are often employed as adulterants. Their characteristic starches are readily recognized.

Adulterations.—The gum is frequently adulterated with other kinds of gum, as cherry, Bdelbin, a gum resin. These, being dark gums, are bleached by means of sulphur or chlorine gas.

The powdered gum is mixed with a great variety of substances, most of which, if of organic structure, are readily detected by the microscope. Other adulterants must be detected by chemical means. Dextrin is a very common adulterant of the powder. A mixture of this latter in gum may be detected by moistening with a few drops of ammonium molybdate and potassium nitrate which when heated gives a blue color.

Uses.—In medicine as a demulcent. In the arts gum arabic has a wide range of usefulness.

Other Gums of Similar Characters.—There are a great number of these, and only the most important can be mentioned. Their chemical composition has been considered.

Cherry and plum gums, from the cultivated and wild cherry and plum trees, are extensively gathered. They exude from natural breaks in the bark of the tree and occur as roundish irregular masses up to one and one-half inches in diameter. Plum gum is lighter in color, cherry gum being more reddish. Both are insoluble in water, but form emulsions. Senaar gum (Talca or Souakim gums) is from North Africa, probably from *Acacia fistula* and *A. Stenocarpa*, Hocht. Jesire gum is from the same general region. Cape gum or South African gum, from *Acacia horrida*, Willd., is a darker, cloudy gum, soluble with difficulty in water. It is

widely used in English commerce mixed with Soudanese varieties. Mesquit gum is derived from a number of species of *Prosopis* of the *Mimoseæ*, plants allied to the *Acacia* and found in the west and southwest part of Texas and California, Mexico and South America. It is often mixed with the lower grades of gum arabic.

TRAGACANTHA. GUM TRAGACANTH.

A gummy exudation from *Astragalus gummifer*, Labill., and other species of *Astragalus*. (Nat. ord. Leguminoseæ.)

In narrow or broad bands, more or less curved or contorted, marked by parallel lines or ridges, white or faintly yellowish, translucent, horn-like, tough, and rendered more readily pulverized by a temperature of 50° C. (122° F.).

The species of this genus *Astragalus* are very numerous in Asia Minor, at least thirty in number, and of characteristic appearance. The gum is obtained by natural exudation, or from cuts in the bark of the stem or branches.*

The form of the exudate, which is a product of degeneration in the cells of the pith and medullary rays, in part, is due to the kind of incision, and varies according to the conditions of heat and moisture. At times it exudes in flattened, ribbon-like, irregular worm-like, or spherical masses. After drying, the pieces have a horny consistency, are whitish to brownish yellow contorted broad or narrow ribbons or irregular pieces, marked with longitudinal lines. The tragacanth is sorted and the different qualities determined by the size and color of the pieces.

It is tough, not easily cut nor powdered, save at an increased temperature; pure tragacanth should be tasteless, but often it is bitterish from portions of the rind. It swells with water into a gelatinous mass.

* Wiesner: Die Rohstoffe, p. 112, Fig. 23. (After Tschirch.)

In the market three kinds are handled—leaf or flake, consisting of the whitest, flattest pieces, most valuable; stem, or worm-like pieces; and sorts, or smaller rounded pieces. The finer leaf tragacanth usually comes from Asia Minor. A particularly fine variety of the stem tragacanth is frequently termed *vermicelli*. Sorts are usually small exudates or broken pieces of stem and flake.

Microscopically numerous cells may be seen in various stages of retrograde metamorphosis, their cell walls

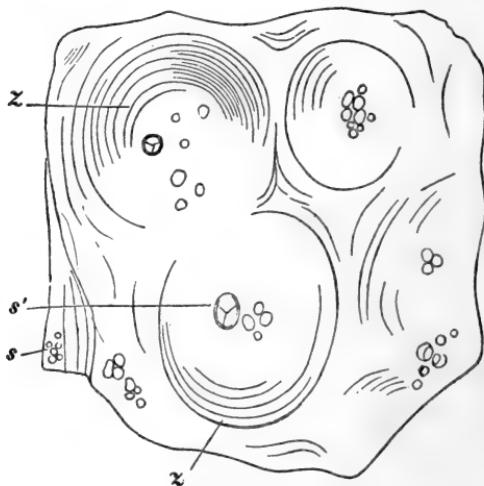


FIG. 3.—TRAGACANTH.

Microscopical view of gum tragacanth: *s, s'*, Remains of starch-grains; *z*, remains of cell-walls (Wiesner).

being swollen in various stages and undergoing the mucilaginous modification. These are mixed with starch grains, which are simple or compound, and measure four to fifteen microns in diameter. Good microscopical pictures can be obtained best from small tear-like pieces. The larger, better sorts often show no trace of histological structure. The tragacanth should be permitted to swell but slightly in order to best bring out its structure.

Chemistry.—Tragacanth consists of varying propor-

tions of *bassorin* (tragacanthin 50 per cent.) and a gum soluble in water. It also contains starch, cellulose, water (14 per cent.), mineral constituents (3 per cent.), sugar, and traces of organic acids and coloring-matters. The soluble gum is not identical with arabin, in that it precipitates with lead acetate.

Adulterations.—Such are not common, as tragacanth is such a typical product. Other gums, such as Caravana and Moussul, have been used. These are said to be derived from wild plum and apricot trees.

OILS, RESINS, OLEORESINS, GUM RESINS, AND BALSAMS.

In taking up this series a complicated and as yet imperfectly understood group of substances is approached. Their chemical structure has been widely investigated, and many facts of vital interest are known, but pharmacologically these bodies are in need of much more extended investigation.

In part it must be remembered that most of these compounds are not simple chemical bodies. They are usually mixtures of resins, oils, gums, and aromatic acids making balsams. Therefore the group of oils, resins, gum resins, and balsams makes a natural group of closely allied substances—physically and chemically, if not pharmacologically.

From the very earliest times the pleasant odors that have been given off by plants have attracted the attention of travelers, and, either because of their odors, agreeable tastes, or medicinal virtues, many of these aromatic plants have entered into the world's commerce up to the present time in their original form, being either previously dried or prepared in some commercially possible manner. With the improvements in technology this class of aromatic compounds, made up for the most

part of this group of oils, resins, and balsams, has been prepared in purer and better conditions.

VOLATILE OILS.

Of the plant products, the spices and aromatics have from the very beginning ministered to the needs and welfare of man, and have, therefore, been appreciated by him in a special degree. As a result, they have been a prominent and influential factor in the intercourse of nations, as well as in the world's commerce. After several thousand years of study and actual use of the spices in their original form, their essential constituents—the volatile oils—have, since the middle ages, and more particularly in modern times, been successfully isolated in their natural freshness and entire efficiency.

A historical retrospect of the part played in history in the commerce of these same spices would prove very interesting, but hardly profitable for present needs, but the trade in spices is as old as civilization and had its early beginnings in the land of Adam and Eve, and much of the exploration of eastern countries was carried on by the spice hunter, the ancient analogue of the gold hunter of to-day.

It has been only within recent years, however, that a true knowledge of the volatile oils has been gained, but it is a most interesting chapter in medicine—that of the use of this class of compounds as incense, cosmetics, and for sanitary purposes. The ancient Egyptians knew that the volatile oils were good antiseptics, even if they did not appreciate that they contained phenols; and it may be well doubted if the embalming art of to-day, with its formaldehyde, carbolic acid, etc., can approach that of the time of the Pharaohs. The Greeks used the spices very widely in medicine—sandal being one of the favorites. The Arabians fostered the process of distilling handed down from the Egyptians.

Ætius, of Amida, a physician and writer, who lived in Constantinople during the beginning of the sixth century, wrote a treatise on the distilling of empyreumatic (volatile) oils. Rose water was used by the Arabians in the eighth, ninth, and tenth centuries as an eye-wash, and rose oil sugar was employed much as we employ turpentine on a lump of sugar for intestinal flatus by the physicians of the Caliph of Monaco in the tenth century. Indeed, rose oil and camphor were current remedies throughout these times. The use of alcohol to extract the volatile oils was taken up in the beginning of the fourteenth century, and distilled aromatic waters and alcoholic solutions of aromatics were very widely employed in medicine. The alchemistic chemical literature of the Middle Ages is filled with the discoveries of the various volatile oils that could be extracted from plants.

It is of interest to note that one of the greatest of all "quacks," as judged by modern standards, Paracelsus (1493-1541), was the real founder of a school that taught that it was the chemical substance within a drug that was the real agent of value and not the whole drug (Iatro-chemical school), an idea that was pregnant with large results.

The modern era of knowledge concerning volatile oils may be said to have begun with the analysis of the stearoptens by Dumas in 1833, and following him a host of chemists have cleared up the chemical composition of a number of important series of compounds, although there are yet many unknown factors in their construction. Hoffman, an authority, says that the chemistry of the volatile oils is but in its initial stages, and who will dare say that their pharmacology is by any means clearly understood? It is not many years since menthol was introduced into medicine, and it is but a forerunner of a large class of similar bodies whose limitation of action must first be studied.

The volatile oils are widely distributed in the vegetable kingdom. The phanerogams or flowering plants are particularly rich in them. From the cryptogams volatile oils are known only from the male-fern, *Dryopteris Filix mas*, and possibly from ergot. These oils are found in the various organs of the plant, the leaves, stem, flowers, fruits, and roots. The microscopical examination shows the oils to exist in special glandular structures, either on the surface of the leaves, as in peppermint, or in special secretory passages in the structure of the plant, as in turpentine or in eucalyptus, etc.

What function the volatile oils may serve in the plant economy is a matter of much conjecture. They are probably katabolic products so far as the metabolism of the plant is concerned; but there is little doubt but that in the case of many fruits their extreme pungency is self-conservative to the plant, protecting it from the ravages of insects, birds, and mammals. The biting taste of many of the leaves also probably contributes to their preservation from animal, notably insect, destruction.

The volatile oils, it should first be impressed, are not definite chemical compounds. They are complex mixtures of many substances belonging to many classes of compounds. The volatile oil from one and the same plant shows many variations in structure, according to the part of the plant used, and radical differences in the odor, physical properties, and physiological action may be found in the oils derived from different organs of a plant, the stem and the flowers, for instance. This variation in chemical structure of many drugs is a cardinal principle.

Volatile oils, however, are grouped under one generic head because they are prepared in much the same manner and because they possess many common physical and chemical characteristics, and in so much as they are

similar in their chemical characters they react similarly physiologically.

In elemental composition volatile oils are alike. They all contain carbon and hydrogen. Most of them contain oxygen and a few contain nitrogen or sulphur, or both. Most of the volatile oils contain many hydrocarbons and other compounds as well. These compounds belong to either the aliphatic organic compounds, or to the aromatic series, and a number of classes of these are found. The hydrocarbons are of wide occurrence, particularly terpenes, $C_{10}H_{16}$. From the standpoint of the perfumer the oxygenated compounds are the most important, since they impart the characteristic odors.

The other compounds found associated with the hydrocarbons may be alcohols, aldehydes, esters, ketones, phenols, phenolethers, lactones, oxides, sulphides, nitriles, and isothiocyanates.

The *hydrocarbons* of both aliphatic and aromatic nature are known; heptane, C_7H_{16} , from a species of pine, being the lowest paraffine. The higher hydrocarbons of this series include many of the waxes and waxy-like coatings of leaves. The wax candles made by the early colonists from the waxberry, or *Myrica*, represent some of these higher hydrocarbons of this paraffine group. The oils from arnica flowers, from chamomile, dill, caraway, sassafras leaf, wintergreen, sweet birch, and wild bergamot contain members of this series.

In the aromatic series the more characteristic volatile oils are obtained. Styrene ($C_6H_5 \cdot CH=CH_2$) represents the lowest of this group. It is found in oil of storax, and probably results from the breaking-down of cinnamic acid.

The principal aromatic hydrocarbons belong to the class of *terpenes*, with the general formula $C_{10}H_{16}$. The majority of these are found ready formed in the plant.

The more important terpenes are the following: *Pinene*, from various species of *Pinus*. It is an important constituent of turpentine and is one of the few terpenes obtained in a pure state. Artificial camphor is a halogen compound, $C_{10}H_{16}HCl$. *Camphene*, from volatile oils of ginger, spike, citronella, turpentine, valerian, camphor oil, and others. It is the only solid terpene known, all the others being mobile liquids, which on exposure to the air, oxidize and are converted into resins. *Limonene*, from the oils of orange, lemon, bergamot, mandarin, neroli, caraway, dill, fennel, celery, and others, is one of the most widely distributed of the terpenes. *Phellandrene*, from the oils of anise, fennel, elemi, star-anise, ginger, curcuma, pepper, camphor, angelica, sassafras leaves, Ceylon cinnamon, golden rod, lemon bay, peppermint, etc., is one of the most unstable of the terpenes.

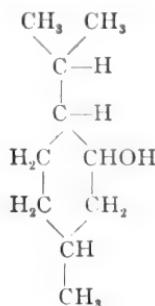
Another class of hydrocarbons is the *sesqui-terpenes*, $C_{15}H_{24}$. These are polymerized products of hemiterpene, C_5H_8 . They have been studied but slightly. *Cadinene*, which is found in many oils, cade, savin, cedarwood, cubeb, asafetida, ylang ylang, camphor, etc., is the most important. *Caryophyllene*, found in cloves and in balsam of copaiba, is another. *Humulene* is a sesqui-terpene in the oil of hops.

Alcohols are common in the volatile oils. They are seldom free alcohols, however, the combinations being with fatty acids and esters. Methyl alcohol, as methyl salicylate, is one of the most widely distributed. Ethyl esters, propyl and butyl combinations, hexyl and octyl alcohols are known.

Olefin alcohols are also present. *Linalool* is one of the most important and widespread. It occurs in the oils of spike, lavender, sage, thyme, bergamot, origanum, ylang ylang, sassafras leaf, etc. *Linalool acetate* is the most important ingredient of bergamot oil. *Geraniol*, di olefinic alcohol, $C_{10}H_{18}O$, is isomeric with the former.

It is characteristic of the oils of geranium, lemongrass, citronella, lavender, sassafras leaf.

Aromatic alcohols are few, but of practical interest. Benzyl alcohol, as benzoates and cinnamates, is of importance in the balsams of tolu and Peru. Other important members of this group are *terpineol*, *borneol*, and *menthol*. The two latter are camphor-like bodies, the former prevalent in Borneol camphor, and in the oils of spike, rosemary, sage, thyme, etc.; menthol is a characteristic ingredient of the peppermint oils. It is a saturated secondary alcohol, as follows:



Aldehydes are frequent and impart characteristic odors. *Citral*, *citronellal*, *benzaldehyde*, and *cinnamic aldehyde* are the most important.

Ketones are few in number. *Carvone*, *camphor*, *thujone*, and *pulegone* are ketones. Ordinary camphor, or Japan camphor, $\text{C}_{10}\text{H}_{16}\text{O}$, distinguished from Borneol camphor, is the most important of this group.

Within recent years a number of phenols have been obtained from the volatile oils and prepared on a large scale. The most important of these are *thymol* ($\text{C}_6\text{H}_3\text{CH}_3$, $\text{C}_3\text{H}_7\text{OH}$) (methyl propyl phenol), from thyme; *carvacrol*, from origanum oil; *anethol*, from anise; *eugenol*, from the oil of cloves. Closely related to these phenols is *apiol*, which is found in the oil of parsley.

Of less frequent occurrence and yet of interest are the nitrogen and sulphur compounds found in the mustard

oils and oil of bitter almonds, cherry laurel, and wild cherry bark. In wild cherry bark, cherry laurel, the nitrile compounds form the basis of hydrocyanic acid (HCN), which is the nitrile of formic acid, HCOH(N), whereas the sulphur compounds found in mustard oils make the volatile oil of mustard and impart to it its rubefacient and stimulating qualities.

It can be seen, therefore, from the consideration of the chemistry of this class of bodies, that whereas terpenes are to be found in all of them, the presence of more active compounds, such as the ketones, the phenols, nitrile compounds, and thiocyanates, overshadows the weaker terpenes physiologically. This emphasizes the necessity of making a provisional classification of the volatile oils along chemical rather than botanical lines. A detailed consideration of the various classes from the physiological point of view belongs properly to the subject of pharmacology.

RESINS.

The resins as a class are difficult of definition. They play an important rôle in pharmacy and medicine, however, and a knowledge of their composition is imperative. Like the oils, resins are not definite compounds, but mixtures of chemical substances. In their general gross characters they closely resemble gums in that they are hard and more or less tenacious. They are insoluble in water—a point to be remembered as a feature of chemical incompatibility. For the most part resins are soluble in ether, in alcohol, and in carbon disulphide. They are rich in carbon, poor in oxygen, and lacking in nitrogen, and burn with a sooty flame. No resins are chemical entities. The resin that flows from a wound in a resiniferous plant to-day may differ slightly in the percentage of its chemical constituents from that which flows to-morrow, and the resin derived from one part of

the plant may vary very radically from that obtained from another. The chief chemical constituents of resins are ester-like unstable *resene* (esters of resins, tannols), very stable *resine*, and in some instances aromatic acids, such as cinnamic and benzoic acids, in which instances the resins are frequently termed *Balsams*, although this is not a valid distinction. The balsam fir of the Adirondacks that yields the so-called Canada Balsam, so widely used in microscopy, does not contain any of these aromatic acids, but is nevertheless termed a balsam.

Hard resins and soft resins, or those that will powder and those that will not, was a distinction made by the older chemists, but inasmuch as the differences are really due to the percentages of volatile oil contained, it is evident that such a distinction is not of permanent value.

In general, pharmacognosy distinguishes three kinds of resins: (1) Ordinary resins, (2) gum resins, and (3) balsams. The gum resins are characterized solely by their containing a large percentage of gums. By balsams is meant either ordinary resins which, like turpentine or Canada balsam, are rich in ethereal oils, holding the resin for the most part in solution, making syrup-like compounds, or those bodies which are really poor in resins, but are made up of resin-like substances with aromatic acids, like benzoic or cinnamic acids—such as is seen in Balsam of Tolu, Balsam of Peru, *Styrax*, etc.

Color, transparency, hardness, fracture, tenacity, and streak are all features of pharmacognostic interest. The solubility of resinous bodies is of importance. The resins are insoluble in water; the gum resins, especially those very rich in gums, make emulsions when mixed with water. Solubility in alcohol, ether, carbon disulphide, turpentine oil, benzol, petroleum, ether, and acetone varies widely, but these are the best solvents. The reaction of resins and gum resins to chloral hydrate is of chemical interest. Many are completely soluble in

46 VEGETABLE DRUGS WITHOUT ORGANIC STRUCTURE.

chloral hydrate, 60 per cent. solution. Some, particularly the fossil resins, simply swell up. Chloral hydrate, 60 per cent. solution, is one of the few solvents that puts both gum and resin in the gum resins into solution.

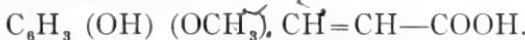
As to the formation of the resins in plant tissues it is enough to know that they exist either in special secretory channels, usually in the woody portions of the plant, or they flow into the tissues and make artificial passages for themselves. As to the origin of the resins, they may be considered in part as retrogressive metamorphic products, largely from tannins, cellulose and from starch, but there are many exceptions.

Chemically it has been pointed out already that the resins are extremely complex, as would be supposed when one considers the different sources from which they may come. The whole subject is a fascinating one, yet very complicated. It may be considered, however, that many of the resins start as oxidized products of some of the terpenes. In fact, most of the resins show series of compounds, as esters, alcohols, etc., that shows either their origin from volatile oils, or a like origin for each class of compound by metamorphosis of the cellulose and starch constituents in the cell wall or in the cell body. Polymerized terpenes seem abundant in the resins (C_5H_8 , $C_{10}H_{16}$, $C_{15}H_{24}$, $C_{20}H_{32}$). Sesquiterpene ($C_{15}H_{24}$) is present in a number of resins—Cade, Galbanum, Olibanum, Asafetida, Copaiba.

Thus it becomes evident that in this class of bodies one finds a closely allied series of compounds of like though varying composition, and it would be natural to suppose that pharmacologically and therapeutically they form allied groups. This is the fact, and if the knowledge of the elementary composition of a drug teaches that one has to deal with certain volatile oils or resins or balsams, then one knows at once what may be expected pharmacologically and therapeutically.

As an illustration of the extreme complexity of the resins the following chemical formula for Asafoetida is shown:*

(1) Free ferulic acid.



(2) Vanillin, $\text{C}_6\text{H}_3(\text{OH})(\text{OCH}_3)\text{CHO}$.

(3) Ethereal oil. This contains

Terpene, $\text{C}_{10}\text{H}_{16}$

Disulphids $\text{C}_7\text{H}_{14}\text{S}_2$

$\text{C}_{11}\text{H}_{20}\text{S}_2$

$(\text{C}_{10}\text{H}_{16}\text{O})n$

$\text{C}_8\text{H}_{16}\text{S}_2$

$\text{C}_{10}\text{H}_{18}\text{S}_2$

(4) Gum. Ether insol.

(5) Resin. (Asa resinotannol, $\text{C}_{24}\text{H}_{33}\text{O}_4$, OH.)

(6) Ether sol. resin—asa resinotannol—which yields Resorcin, $\text{C}_6\text{H}_4(\text{OH})_2$.

Protocatechuic acid, $\text{C}_6\text{H}_3(\text{OH})_2\text{COOH}$.

As an illustration of the complexity of a balsam the ultimate chemical analysis of Balsam of Peru is as follows:

(1) Free cinnamic acid, C. ald., $\text{C}_6\text{H}_5\text{CH}(\text{CH}_3)\text{COH}$.

(2) Vanillin, $\text{C}_6\text{H}_3(\text{OH})(\text{OCH}_3)\text{CHO}$.

(3) Cinnamein (fluid portion of balsam), consisting of much benzoic acid, benzyl esters, $\text{C}_6\text{H}_5\text{COOCH}_2\text{C}_6\text{H}_5$.

Little cinnamic acid benzyl ester,

Peruviol ($\text{C}_{13}\text{H}_{22}\text{O}$), $\text{C}_6\text{H}_5\text{CH}$ equals $\text{CH}_2\text{C}_6\text{H}_5$.

(4) Resin. Ester of Peru resinotannol, $\text{C}_{18}\text{H}_{19}\text{O}_4\text{OH}$, which yields cinnamic acid, benzoic and the Peru resinotannol, $\text{C}_{18}\text{H}_{19}\text{O}_4\text{OH}$.

Only the more important of this group will be here studied.

* Wiesner: Die Rohstoffe des Pflanzenreichs. Hoffman, Volatile Oils. Tschirch, Die Härze.

CAMPHORA. CAMPHOR.

Camphora is a stearopten (having the nature of a ketone) obtained from *Cinnamomum Camphora* (Linné), Nees et Ebermaier, and purified by sublimation.

Cinnamomum Camphora is a tree 100 to 150 feet high, a native of eastern Asia, where it is found in large numbers, both cultivated and wild. Camphor tree contains camphor in all parts of the plant (perhaps failing a little in the flowers), either in crystalline form or dissolved in ethereal oil.

By processes of oxidation camphor, $C_{10}H_{16}O$, is formed. The method of preparing for commerce varies somewhat in the different provinces where it is manufactured. In Formosa the trees are felled and the stem reduced to chips. These are brought to simple ovens and exposed to steam, and the vapors arising containing camphor are condensed on the inside of rude receptacles, sometimes iron pots, and from these scraped and sent for sublimation. The Formosa camphor thus prepared is crude, dark, and impure.

In many of the Japanese provinces the chips and portions of the plant are boiled in water in iron pots, the vapor which arises condensing on straw or bamboo, from which it is broken and packed for subsequent purification. Japanese crude camphor is somewhat reddish in tint.

In the refining processes the crude camphor, which has a variety of foreign bodies included in it, is mixed with various materials, coal, sand, or iron filings, heated over a sand-bath, sublimed, and collected. In some American manufactories the vapor is received in a cooling room and precipitated as is sulphur. It is then pressed in cakes and in this shape appears in the market.

Description.—It is white, translucent, irregular, crystalline, waxy, shining, solid, breaking with a waxy tough

fracture. The odor is characteristic, the taste somewhat aromatic and at first burning, later bitter with after-effect of cooling. Its specific gravity is 0.993; it melts at 175° C.; sublimes at 200° C. Camphor is volatile at ordinary temperature. It powders with any liquid in which it is insoluble. It crystallizes in the hexagonal system; is soluble in 1200 parts of water and is readily soluble in alcohol, ether, chloroform, glacial acetic acid, carbon disulphide, acetone, and benzol. It liquefies with chloral hydrate, or phenol, thymol, resorcin, etc.

Chemistry.—Pure camphor is $C_{10}H_{16}O$, a ketone which does not combine with bisulphites, but from this a large number of derivatives are made by heating with other substances.

Camphor is now being made from turpentine on a large scale.

TEREBINTHINA. TURPENTINE.

Turpentine is a concrete oleoresin obtained from *Pinus palustris*, Miller, and from other species of *Pinus*.

It is sometimes termed *Terebinthina communis*, in distinction from *Terebinthina Canadensis* and *Terebinthina Venetia*.

Terebinthina is derived mainly in the United States from *Pinus palustris* and *Pinus Taeda*, but almost all of the larger pines yield it. The habitat from which most of it is gathered is on the east coast from Canada to Florida and west to Texas. Much is also being gathered in the woods of Canada and the Northwest. Commercially North Carolina and Georgia furnish most.

Turpentine exudes naturally, but the process is slow. For commercial purposes deep incisions or gouges are made in the trees and the resin collected in troughs. The earlier incisions give the best product. In the following years the flow (yellow dip) is scanty, and the products give but four gallons of oil to the barrel, in

comparison with six given by the first or virgin dip. Scrapings are even less rich in oil, giving one to two gallons to the barrel.

In its crude liquid state it is rarely seen on the market, but in its more solid form it consists of yellowish, opaque, tough, sticky masses; when cold, crumbly and brittle. The odor is peculiar, the taste bitter, acrid, and somewhat aromatic. Purer kinds are apt to be whiter; the less valuable ones yellowish to brownish and blackish, with much chip and scrapings.

The resin in the tree is dissolved in the oil and is formed in special secretory passages by the metamorphosis of the lining cells of these passages.

Chemistry.—Turpentine is a resin dissolved in ethereal oil. This oil of turpentine will vary from 15 to 30 per cent.; the resin or rosin of commerce (*Colophonium*) ranging from 60 to 80 per cent.; water, 5 to 10 per cent., holding bitter stuff in solution, precipitated by tannic acid; small quantities of abietinic acid ($C_{44}H_{64}O_5$).

TEREBINTHINA VENETIA. VENICE TURPENTINE.

Venice turpentine is derived from the European larch, *Larix Europea*, by boring holes to the center, from which the resin slowly flows. It was handled in the tenth century by the Venetians, hence the name. The tree is native throughout the greater part of Europe, but the parts where it is much used are southern France, northern Italy, a little in the southern Tyrol, and much in Styria.

The holes are plugged during the winter, but in the following spring the plugs are withdrawn and more oleoresin collected, the process being repeated yearly.

Description.—It occurs in clear to yellowish and brownish masses, transparent in the finer grades, after being kept some time apt to show slight fluorescence. Solidifies slowly, non-crystalline. The odor is terebinthinate

and balsamic, taste aromatic to bitter and finally acrid. Miscible with absolute alcohol, acetone, acetic acid, amyl alcohol. Polarizes light to right.

Chemistry.—The ethereal oil—15 per cent.—is made up of two parts, one distilling at 157° F., the other, smaller, at 190° F. The resin is freely soluble in acetone, alcohol, and benzol.

Adulterations.—Other resins dissolved in turpentine.

CANADIAN TURPENTINE.

Canadian Turpentine is an oleoresin derived from *Abies balsama*, a tree of the northern parts of North America, also extending southward along the high mountains as far as Virginia.

The oleoresin is contained in superficial secretory passages lying mainly in the outer bark. These are somewhat flattened, blister-shaped, and are punctured with appropriate instruments, the turpentine issuing from them as a viscous fluid with a yellowish or greenish color, sometimes slightly fluorescent. It has a pleasant and durable aromatic odor. The taste is terebinthinate and sharp, at times acrid.

Chemistry.—Water extracts a bitter stuff; oil, 20 to 25 per cent.; resin, elastic or tenacious and clear yellowish. Ethereal oil consists of a carbohydrate, $C_{10}H_{16}$, and a small amount of an acid oil; the two differentiate at 167° and 170° F., respectively.

The resin of Canada balsam rotates light to the right, is non-crystalline, refraction index 1.52, soluble in absolute alcohol, 75 per cent. residue in ether, soluble in xylol, chloroform, benzol. It remains clear and darkens slightly on standing.

COLOPHONIUM. RESIN. ROSIN.

Colophonium is the residue left after distilling off the volatile oil from turpentine.

A transparent, amber-colored substance, hard, pulverizable; fracture glassy and shallow conchoidal; odor and taste faintly terebinthinate.

The better kinds of colophonium are yellowish to brown, transparent, breaking with a very splintery, shallow and conchoidal fracture. It melts at about 90° to 100° C. The pieces vary in shape and size. The inferior grades vary from greenish, brownish to blackish red. These shades are due to the heat of distillation, and in part to the species of pine yielding the resin.

Rosin is soluble in alcohol, acetone, ether, chloroform, CS_2 , which solutions show a mild fluorescence and chloral hydrate. With solution of KOH and NaOH it forms rosin soaps. Taste and odor terebinthinate.

Colophonium is derived mainly from *Pinus palustris*, Miller, and other species of pine, found largely in the United States.

Chemistry.—A certain amount of residual turpentine is always present and generally a small percentage of water. It also contains pinic and sylvic acids, and the anhydride of abietic acid ($\text{C}_{44}\text{H}_{62}\text{O}_4$), which latter is the most important ingredient.

By dry distillation a large number of products are obtained, one of the many being a resin oil, Harzol, consisting of methyl alcohol and a heptan, C_7H_{16} , with other derivatives.

DAMMAR.

Dammar is a resinous exudation or a mixture of resins from a vast variety of sources. That which is usually found in the European and American markets is derived from *Dammara officinalis*, Lamb., or *Agathis Dammara*, Rich., a member of the *Abietineæ*, a native of Molucca and East Indian Islands, also of the Philippines and New Zealand.*

* Concerning the many doubts which have been raised regarding the origin of this resin consult Wiesner: *Die Rohstoffe des Pflanzenreichs*, new edition, p. 253.

It flows spontaneously from the main stems and also from the roots. In some regions, as the mountains of Sumatra, the resin falls in large masses from spontaneous fissures; in other regions wounds are made in the trees, with a corresponding greater yield of resin. It comes into commerce in large masses five to fifteen inches in diameter, or in small pieces one to three inches in diameter.

It is light yellowish, transparent in small pieces, smooth, fragile, breaking with clean, conchoidal, glassy fracture, and is readily powdered. It melts at about 120° C. and is intermediate in hardness between Colophonium, which melts at 100° C., and Copal, melting at 180° C. The fresh resin has a terebinthinate odor and taste, but older specimens may be odorless and tasteless.

Chemistry.—It contains traces of an ethereal oil, dammarolic acid, $C_{54}H_{77}O_3(OH)(COOH)_2$, and two resins.*

It is insoluble in water, partly soluble in cold alcohol and ether, completely soluble in benzol, xylol, chloroform, CS_2 , soluble in concentrated H_2SO_4 , with red color, and is thrown down by water as a white powdery precipitate from this solution; it is partly soluble in ether, alcohol, toluol, acetic acid, petroleum ether, acetone, and anilin. In an 80 per cent. solution of chloral hydrate it swells very markedly, but does not become soluble even after extended action of the chloral.

* Tschirch and Glimann, Arch. der Pharmacie, 234, 1896, p. 585, have determined the composition about as follows:

Dammarolic acid	23.0	per cent.
Water	2.5	"
Ash	3.5	"
Impurities	8.0	"
A. Dammar-Resin, sol. in alcohol	40.0	"
B. Dammar-Resin, insol. in alcohol	22.5	"
Residue—Ethereal oil, bitter principles, etc.	0.5	"
<hr/>		
	100.0	

COPAL.

The different copal resins are derived from a great variety of plants, both fossil and recent, the botanical names of which are not definitely determined. The name is applied to a number of extremely hard resins; softer varieties appear in the English market under the name *Animi*. The harder sorts of copal are derived from fossiliferous trees.

In the recent state the resins may be obtained from species of *Trachylobium mossambicense*, Klotzsch, *Hymenaea* and *Guibourtia copallifera*, from Africa, South America, and the West Indies.

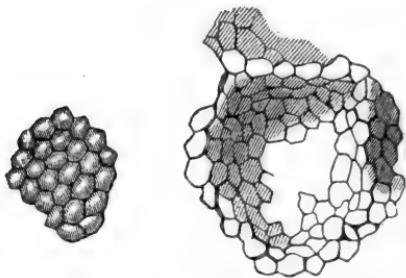


FIG. 4.—COPAL.
Superficial view of gum copal.

variety, covered with a crust in the South American copals. It is hard, in the mineral scale about three, transparent or translucent, with a glassy concave fracture, having a tendency to break in six-sided fragments. It is odorless and tasteless.

As the sources from which this resin is derived are numerous and as each kind varies somewhat, the description becomes extremely complicated. A few of the more important kinds may be mentioned.

Zanzibar and Mozambique Copal.—This is found in drops 3 to 10 cm. in diameter or in flattened plates with a transverse diameter of 10 to 20 cm. Opaque, mixed with sand, finely warty. On fracture, which is brittle, the broken

It occurs for the most part in irregular pieces, spherical, flattened or angular, pale yellowish in the better sorts, to reddish and brownish, the surface being irregular and warty, in the Zanzibar and Ancola

surfaces show a yellowish brown, transparent or translucent center. High melting-point up to 300° C.

West African Copals.—A variety of copal comes from different parts of West Africa. These, like southeast African sorts, are usually from recent fossil sources.

South American Copals.—From different members of living Cæsalpiniaceæ, mainly from *Hymenæa Courbarili*, L., and also from *Trachylobium*, *Vouapa*, and *Icica*, species indigenous to Brazil, Guiana, Colombia, and the Antilles. These occur in root-shaped pieces, 10 cm. long, 2 to 3 cm. thick, with irregular warty surface. In color they vary from yellow to deep green, very clear and homogeneous. They are not as hard as the African copals, and they have a lower melting-point, 200° C. The taste is bitter and it has a sourish, mucilaginous odor.

Manila Copals.—Varieties of copal resin are found throughout these Indian islands, Sumatra, Java, Borneo, the Philippines, especially in Luzon and the Moluccas. These copals are widely used, being of the cheaper grades.

They are derived mainly, according to most authors, from *Vateria Indica*, L., but Wiesner is inclined to believe that more of the Manila copals are really derived from *Dammara orientalis*. The copals derived from species of the *Dipterocarpeæ* are distinguished from those derived from the *Coniferaeæ* by the solubility of the former in chloral hydrate. It is largely according to this chemical test that Wiesner rejects *Vateria* as the origin of these Manila copals.

The resin appears as lumpy, root-like, and tear-like fragments. There is no weather crust, such as is seen in the East and West African copals and in the Kauri copal. It is opaque and turbid, becoming clearer in the inner mass. The colors are extremely variable, brownish, gray to milk white, sometimes honey-yellow. The taste is aromatic and the resin adheres to the teeth in biting.

KAURI. COWRIE.

Kauri Resins or Kauri Copals are resins from New Zealand derived from *Dammara Australis*, and in New Caledonia commonly from *Dammara ovata*.

Most of the resin is found imbedded in the earth in the so-called Kauri Fields, which are located in the northern islands. The pieces vary in size, from two to three to eight to ten inches in diameter, mainly roundish, the surface being irregular and showing the effects of weathering. The fracture is brittle and glassy. Externally the fragments are whitish and yellowish, gray or deep brown, even varying widely in a single piece. The color of the resin within varies greatly, yellowish to brownish, changing even in the same piece. Often foreign matters are included, beetles, flies, and pieces of vegetable matter. The odor is balsamic, the taste somewhat woody. The resin softens in the mouth and sticks to the teeth. The melting-point varies from 180° to 240° C.

Chemistry.—The chemical composition of these copals is still in need of much study. Being so very diverse in origin, they vary widely. Tschirch and Stephan* have shown that a specimen of Zanzibar copal has the following composition:

Trachylolic acid, $C_{33}H_{85}O_3(OH)(COOH)_2$	80.0	per cent.
Isochylolic acid (melting pt. 105°-107° C.)	4.0	"
Resin and copal resin	6.0	"
A. resin ($C_{41}H_{88}O_4$), melting pt. 75° C.		
B. resin ($C_{25}H_{38}O_4$), " " 140° C.		
Impurities	0.4	"
Ash	0.12	"
Bitter principles (ethereal oil, etc.)	9.40	"

SANDARAC.

Sandarac is a resin derived from a member of the pine family, *Callitris quadrivalvis*, which is a tree indigenous to the northwestern parts of Africa. It is slightly cultivated in the tropical regions of Europe.

* Archiv der Pharmacie, 234, 1896, p. 552.

The resin lies in oval schizogenous passages which are from three to six in number and are situated in the parenchyma of the inner bark. While in the plant the resin is comparatively fluid, containing ethereal oils, these evaporate readily upon exposure and thus the resin hardens.

The resin is collected from natural and artificial openings in the bark, and occurs in various tear-shaped pieces, elongated, cylindrical, pear-shaped to spherical. The longer pieces are sometimes 2 to 3 cm. in length and 5 mm. in diameter. In warm weather the pieces are liable to run together.

In the finer varieties the color is yellowish, transparent, with sharp, brittle, dusty fracture. This dust usually covers the pieces, giving them their characteristic dull color. Sp. gravity 1.04 to 1.09. It softens at 100° C., and melts at 135° C., giving off an aromatic odor. Inflammable at higher temperature. No ash. The taste is bitterish. On mastication sandarac powders and cannot be chewed. It is soluble in alcohol, 96 per cent., in ether, amyl alcohol, acetone, and ethereal oils, like anise oil. It is less readily soluble in chloroform, CS_2 . It is insoluble in benzol and petroleum ether.

Chemistry.—It contains traces of an ethereal oil which is little known. It contains two free acids, Sandaracol acid, $C_{43}H_{61}O_3(OH)(OCH_3)COOH$, a white crystalline substance with a melting-point of 140° C., and Callitrol acid, $C_{64}H_{82}O_5(OH)COOH$, which forms colorless prisms melting at 248° C. Tschirch and Balzer* give the following composition:—

Sandaracol acid.....	85.00	per cent.
Callitrol acid.....	10.00	"
Water.....	0.56	"
Ash.....	0.10	"
Impurities.....	1.50	"
Bitter stuffs, oil, etc.....	2.84	"
<hr/>		
	100.00	per cent.

* Archiv der Pharmacie, 234, 1896, p. 289.

MASTICHE.

Mastiche is a resin derived from trees of the natural order Anacardiaceæ or the Cashew family, the most common being *Pistacia lentiscus*, a tree about fifteen feet high, a native of the Mediterranean basin.

In the tree the resin lies in a number of passages among the sieve tubes of the phloem portion of the stem, from which it exudes through artificial incisions made about the middle of June. The incisions are made numerous and small, from the root and running up to the branches in a longitudinal direction. The resin in the main stems exudes freely, being very fluid and aromatic. After ten to twenty days it is sufficiently hard to collect and pack. From the twigs the small pea-like pieces are collected. According to Flückiger, the whole process lasts two months and a single tree yields about ten pounds.

Description.—The better sorts of mastiche are small, spherical or ovoidal lumps about 0.5 to 2.0 cm. in diameter, colorless or clear yellow in color, transparent, with a shiny glassy surface, which may later become clouded by means of dust. The fracture is sharp and brittle with little dust. In hardness it is intermediate between dammar and sandarac. The odor is slightly aromatic, the taste somewhat terebinthinate. The resin, when crushed in the teeth, holds together and can be chewed.

Inferior sorts are darker in color, more irregular in shape, and are often contaminated with portions of the bark and with foreign particles and dust.

Chemistry.—Its specific gravity is 1.07. It softens at about 100° C., and melts at 103° to 108° C. It is readily soluble in amyl alcohol and oil of cloves. The greater part is soluble in alcohol; this part has an acid reaction, and has been called X resin or Masticin acid, 80 to 90 per cent., $C_{20}H_{82}O_2$; the insoluble portion, soft or B resin, 10 to 20 per cent., has been termed Masticin, $C_{20}H_{32}O$. It con-

tains also an ethereal oil, one or two per cent. $C_{10}H_{16}$, made up for the most part of pinene. There is a bitter stuff extracted by water.

Other Kinds and Adulterations.—*Pistacia Terebinthina*, from North Africa, yields a mastiche, Chios turpentine, which closely resembles ordinary mastiche. It has the same turpentine taste, but is free from the bitter principle of mastiche, and is more completely soluble in alcohol. A variety of the species also gives a mastiche. Bombay mastiche is by Flückiger regarded as allied with the previous type. This mastiche resembles Chios mastiche closely, is soluble in acetone, rotates light to the right, is generally less yellow and more opaque.

GUAIACI RESINA. GUAIAC.

The resin of the wood of *Guaiacum officinale*, Linné. The heart wood of *Guaiacum officinale*, a tree indigenous to the West Indian Islands and the northern coast of South America, contains 15 to 30 per cent. of resin, and is the chief source of guaiac resin. It may be obtained from deep incisions in the bark, but the usual method of collection is that of extraction by burning. The resin lies in nearly all the elements of the wood, it being particularly rich in the vessels, which are sometimes completely filled.

In the market it appears in irregular pieces, reaching one to one and one-half inches in diameter, the surface somewhat watery, greenish to brownish, dusty. As it is usually mixed with portions of the charred wood its fractured surface will vary considerably, being brownish, greenish, glassy or dirty, according to its purity. Small pure pieces or splinters are transparent, shining, greenish or brownish in color. Freshly powdered the color is grayish brown. Later by oxidation in the air the powder becomes greenish in color. The odor on heating is aromatic. The taste is at first sweet and bitter, later sharp, irritating, and astringent.

60 VEGETABLE DRUGS WITHOUT ORGANIC STRUCTURE.

The specific gravity is about 1.20 and it melts at about 85° C. It is insoluble in water, soluble in alcohol, with brownish yellow color, also soluble in amyl alcohol, chloroform, acetone and caustic alkalies; sparingly soluble in oil of cloves and cumarin. Practically insoluble in petroleum ether, benzol, or carbon disulphide. The alcoholic solution has a slight acid reaction, and by oxidation becomes blue or green, which color is also more rapidly developed on the addition of ferric chloride or other oxidizing agent, as chlorine, iodine, or bromine.

The resin consists of (a) Guaiaconic acid, $C_{20}H_{22}O_3$ (OH)₂, which makes up about 70 per cent. of the resin. It is amorphous, bright brown, odorless and tasteless, melts at 95° to 100° C., is insoluble in water, easily soluble in alcohol, ether, acetic acid, and chloroform. The salts are amorphous, the alkali salts soluble in water and alcohol.

(b) Guaiaretic acid (Guaiac resin acid, $C_{18}H_{18}(OCH_3)_2$ (OH)₂), about 10 per cent. From alcoholic solution it crystallizes out as rhombic needles, which have a slight vanilla-like odor, melts at 75° to 80° C., is insoluble in water, soluble in ether, chloroform, acetic acid, benzol. Its alkaline salts are crystalline and are soluble in water.

(c) Guaiac beta resin; $C_{20}H_{19}O_4(OH)_3$, about 10 per cent. Insoluble in ether.

(d) Guaiac acid; $C_6H_8O_3$, sparingly found.

(e) Guaiac yellow; $C_{20}H_{20}O_7$, the yellow coloring-matter of the resin, odorless, bitter, easily soluble in alcohol, ether, carbon disulphide.

By destructive distillation a number of products are obtained. Tiglin aldehyd, $CH(CH_3)$; guaiacol, $C_6H_4(OH)(OCH_3)$, and pyroguaiaicin, $C_{12}H_{10}(OH)(OCH_3)$, and creosol, $C_6H_5(OH)(OCH_3)(CH_3)$, are among the most important.

Adulterations.—Guaiac is frequently adulterated by colophonium; its turpentine odor is usually sufficient to detect the sophistication.

BENZOINUM. BENZOIN.

Benzoinum is a balsamic resin obtained from *Styrax Benzoin*, Dryander, a medium-sized tree native of Sumatra, and portions of India, in which places it is also extensively cultivated. It is probable that the Siam variety is derived from another source.* The resin has its origin for the most part in the cells of the middle bark, but the secondary medullary ray cells also contain some resin. The contents of the resin-producing cells are at first increased, the cell becomes swollen, and later there appear drops of resin within the cell. The cell walls then break down, being absorbed from the inside, which results in the formation of lysigenous passages in the bark. These gradually increase to a large size.

Artificial incisions are made in the bark in April and May from which the clear resin flows; that from the younger trees (five years) being the best quality. As the tree grows older the resin grows darker, and when the tree is about twenty years old it is frequently cut, and yields, along with pieces of wood and bark, inferior grades. The terms *head*, *belly*, and *foot* benzoin have been used to designate the benzoin derived from the trees at these respective times.

The resin is received at Sumatra or Bangkok in canoes, sampans, and is sent from there to the ports of export, Singapore, etc.

Several varieties need to be distinguished. These are Sumatra, Siam, Penang, etc.

Sumatra benzoin comes in large masses. These are somewhat irregular and porous, and have a general reddish or greenish brown color. Imbedded here and there are a number of whiter pearls or "mandels," 3 to 5 cm. in diameter. The relatively greater number of these mandels indicates a better sort of benzoin. Inferior

* Flückiger: Pharmakognosie; Holmes: Phar. Trans., 1891, p. 518.

grades are very poor in "mandels," or tears, the product is darker brown, more porous, and has a greater admixture of foreign matter, chips, pieces of bark, sand, etc.

The general melting-point is about 90° C., that of the tears about 85° C. It has a pleasant odor, made more evident by warming, and a somewhat aromatic and later biting taste. When chewed it at first becomes powdery, but later the pieces adhere in masses.

Penang benzoin may be a fine variety of Sumatra.

Siam benzoin is a much more highly prized benzoin and appears in the market in different ways. Sometimes it comes in more or less loosely agglutinated tears, at other times in masses, somewhat resembling the Sumatra benzoin. The former is a purer variety, and the mass consists almost exclusively of tears, 2, 3 to 5 cm. in diameter; these are almond to pebble-shaped masses, of an orange or brownish red color. Their fracture is soft, somewhat fatty, the outer layer being somewhat reddish. Inside the color is a pearly white, which later, on exposure to the air, becomes reddish. The masses are somewhat similar to those of Sumatra, but are darker yellow or brown and whitish, or pure white internally.

The melting-point is about 75° C. The odor is stronger and more suggestive of vanilla. The taste is similar to that of the Sumatra variety. Foreign bodies are also likely to be included.

Chemistry.—The drug consists of from 70 to 80 per cent. of amorphous resin, 14 to 24 per cent. of free benzoic acid, ethereal oils, cinnamic acid.

Tschirch and Ludy* give the following composition for Sumatra benzoin:

Benzaldehyd	Traces
Benzal	Traces
Vanillin	1.0
Phenylpropylester of Cinnamic Acid	1.0
Styracin	2.0-3.0
Resins	75.0
Woody impurities	14.0-17.0

* Archiv der Pharmacie, 231, 1893, p. 43.

The resins are two, the Cinnamic acid benzoresinol ester, $C_{16}H_{25}O_2$, C_9H_7O ; and the Cinnamic acid suma resino tannol ester, $C_{18}H_{19}O_4$, C_9H_7O . These esters are broken up into benzoresinol, 5.2 per cent., resinotannol, 64.5 per cent., and cinnamic acid, 30.3 per cent.

COPAIBA. BALSAM OF COPAIBA.

✓ *Copaiba* is the oleoresin of *Copaifera Langsdorffii* (Desfontaines), O. Kuntze, and of other species of *Copaifera*.

The species of *Copaifera* are members of the family

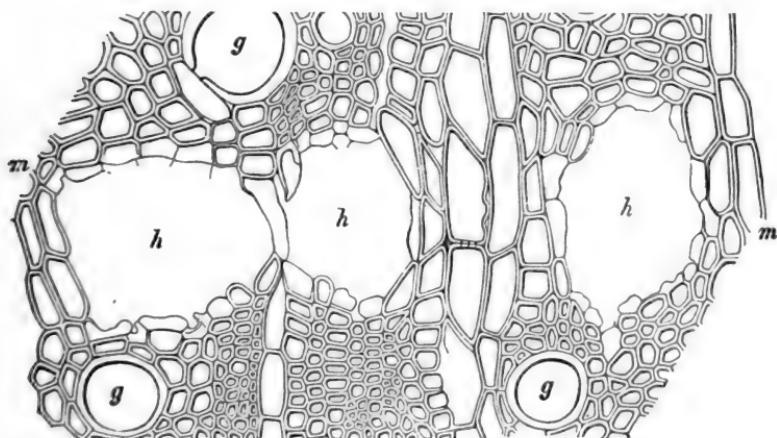


FIG. 5.—COPAIBA.

Resin-passages in wood of copaiba: *m*, Medullary rays; *g*, vessels; *h*, resin-passages.

Leguminosæ, and are widely distributed in the regions of Brazil, Venezuela and the northern portion of South America generally, Costa Rica and the West Indies also.* They are trees and there are about ten species that are widely used. Those from which the balsam is collected are for the most part: *Copaifera officinalis* Jacq., *Copaifera Guyanensis* (Desf.) O. Kuntze, *Copaifera coriacea* (Mart.) O. Kuntze, and *Copaifera Langsdorffii*. Occasionally, in addition to these main species,

* Karsten, Bot. Ztg. XV, 316, 1859.

Copaifera confertiflora, *Copaifera oblongifolia*, and *Copaifera multijuga*, also give balsam.

The balsam is found in large, lysigenous passages in the wood of the plant, resulting from a degeneration of some of the xylem elements, at first the woody parenchyma, later the vessels. These passages may become long channels over an inch in diameter, traversing almost the entire length of the trunk of the tree. The resin is found in passages in the leaves also.

For commercial purposes the resin is obtained by boring holes or making half round or triangular incisions (boxes) deep into the heart wood of the tree. These holes or "boxes" soon fill with resin, and as it flows out it is collected in appropriate vessels. As much as ten to fifteen pounds may flow in twenty-four hours. After tapping or if unsuccessfully tapped, the wound is closed and revisited, the tapped trees usually yielding after an interval. The trees are tapped as much as three times a year.

The chief export towns are in Brazil and Venezuela, which give the names to the chief varieties exported, thus: Rio, Para, Maranham, and Maracaibo balsams. Slight differences exist in each.

Description.—The resin varies within narrow limits, according to the age and amount of evaporation of the oil. In general it is a somewhat viscid liquid, yellowish to brownish in color. It is generally clear, at times turbid. The product from Para is lighter in color and thinner in consistency, whereas that from Maracaibo is the thickest and brownest. The specific gravity varies from 0.93 to 1.2.

The odor is aromatic and characteristic; the taste sharp and bitter. It is soluble in absolute alcohol, ether, chloroform, benzol, carbon disulphide, also in fixed and volatile oils.

Chemistry.—Balsam of Copiba consists of solutions

of resins in ethereal oils. Para contains 60 to 80 per cent. oil; Maranham, 40 to 60 per cent.; Maracaibo, 20 to 90 per cent.

Copaiba oil is a mixture of isomeric hydrocarbons, the sesquiterpene, caryophyllen, $C_{15}H_{24}$, being, according to Hoffe, the only definitely known constituent. It is a colorless, yellowish, or brownish liquid, specific gravity 0.900 to 0.910, with a boiling-point of 250° to 275° C. It is laevorotary.

The acids are copaivic, oxycopaivic, and metacopaivic acid, varying in the different varieties.

The resin is a liquid, amorphous mass which is acid in reaction and brittle. There is also a bitter principle which is soluble in water.

Adulterations.—The most common adulterant is turpentine; also other oils, linseed, castor, and, recently, cottonseed. The first is recognized by the odor on heating, the fixed oils by the lower boiling-point, and by their leaving a heavy, sticky residue. 

ASAFOETIDA.

Asafoetida is a gum resin obtained from the root of *Ferula fætida* (Bunge), Regel.

Although the Pharmacopœia limits the producing plant, it is quite probable that asafoetida is obtained from two or even three or four species of *Ferula*. (*Peucedanum*.) Some of these are *Ferula Narthex* (mentioned in the Pharmacopœia of 1880), a native of northwestern Thibet; *Ferula fætidissima*, east Persia (*Peucedanum albacein*, Baillon); *Ferula Jaschkeanum*, Vatke (P. J. Baillon), a native of Cashmere.

The main sources are, however, *Ferula fætida* and *Ferula Narthex*. The former is a tall, coarse herb of the *Umbellifereæ*, five to ten feet high, widely distributed in the Eastern Asiatic provinces, from Persia, Turkestan, and Afghanistan.

Production.—The product, in the form of milky juice, is found throughout the plant, but that coming from the root is alone used. In the root it is formed by small cells which line large, long and unbranched schizogenous passages, richest in the parenchyma of the bark.

The milk sap canals in the secondary bark are very large, their diameter being as great as 70 to 130 microns in *Ferula Narthex*; 130 microns in *Ferula albacea*. Sometimes a number of canals will coalesce, forming a passage 560 to 600 microns in diameter. They have a concentric arrangement.

The passages in the vessel portion of the plant are generally much narrower, from 80 to 40 microns in diameter.

In most of the accounts given of the collection, in the main, it is said that the root is carefully cleaned from withering leaves and then cut off close to the ground, while a shallow

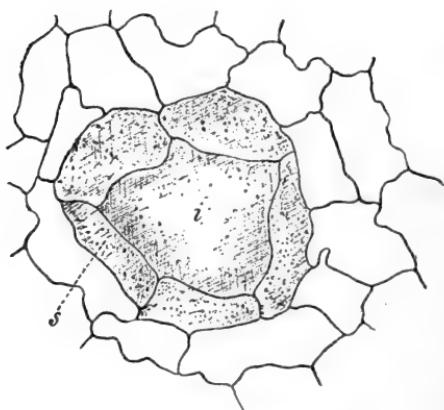


FIG. 6.—ASAFOETIDA.

Milk-canal containing secretion in root:
s, Secretory cells; i, secretory passage.

low pit is made about its base. The entire plant is thus covered over with leaves for five to six weeks. In May the covering is removed and a thin slice of the root is cut off and the juice that exudes is scraped off into appropriate receptacles. The plant is then covered, and in a few days, three to ten, a second slice is taken and the process repeated until the root is exhausted.

Description.—The juice first collected is apt to be thin, and it is this earlier juice that is apt to be adulterated with

organic matter, clay, stones, gypsum, etc., the ingenuity of the natives sometimes being remarkable. The later product, especially if care has been taken in the collecting, is thicker and more resinous and yields the better type of gum resin.

The milky juice as it first exudes is whitish; then by oxidation it becomes reddish to violet, and later, brown. In the market there appear several grades running gradually one into another, from the liquid *amygdaloid*, *tears* to *stony*, representing different grades of hardness, and the predominance of certain kinds of lumps in the mass. In the warmer and temperate climates, at least, most of the asafoetida becomes amalgamated into masses; the embedding substance being reddish to brownish and holding a number of roundish, tear-like or granular masses, which have a wax-like fracture, are whitish in the center, but undergo the same color changes.

The better the sort of asafoetida, the greater the number of tears and the less the embedding substance, and vice versa, the poorer sorts containing impurities up to 50, 60, or even 70 per cent. of the entire mass. Two sorts alone are regularly recognized in commerce, *Tear* and *Lump*.

The odor is peculiar, somewhat alliaceous, and the taste is sharp, bitter, and persistent.

Under the microscope the appearance is of an un-homogeneous mass. If small pieces of asafoetida are examined in oil, the main portions resemble a homogeneous gummy substance with small, spherical, irregular resinous masses sprinkled here and there; in places free from these resinous masses at times; in other places there may be numerous granules of resin and drops of ethereal oil. Mixed with water, an emulsion results with much mechanical motion. This motion, however, is less than that observed when other gum emulsions are studied.

Chemistry.—When cold, good varieties of asafoetida

can be powdered, and when rubbed up with water, yield a milky emulsion. In alcohol it is but partly soluble, 40 to 60 per cent.

In general, asafoetida consists of resin, 50 to 70 per cent.; gum, 20 to 30 per cent., allied to, yet distinct from gum arabic; ethereal oil with sulphur as high as 30 per cent.; vanillin, 0.06 per cent.; free ferulic acid, 1.28 per cent.; water and ash and impurities up to 5 per cent. The quantitative proportions vary with the age and goodness of the gum, the softer kinds being richer in oil. The purest asafoetida should yield but 4 per cent. of ash; up to 10 per cent. should not necessarily constitute adulteration, but beyond that amount sophistication is a certainty.

The resin of asafoetida is soluble in alcohol, in acetic acid with a clear solution; in acetone, acetic ether, and chloroform, cloudy; in ether and potassium hydrate, partly soluble; in petroleum ether, carbon disulphide, and benzol, insoluble. Ether separates a soluble and an insoluble portion, the former of which is an asaresinotannol of ferulic acid ester. Sulphuric acid splits this ester up into *umbelliferon*, and a resin alcohol, $C_{24}H_{33}O_4$, OH. The insoluble portion is free asaresinotannol.

The ethereal oil is clear yellowish with the characteristic odor and mild stimulating taste. Specific gravity 0.975 to 0.990. It contains at least one terpene and some sulphur compounds.

GALBANUM. MOTHER RESIN.

Galbanum is a gum derived from different species of *Ferula*, *Ferula galbaniflua*, H. Baillon, a plant of northern Persia, and *Ferula rubricaulis*, Boissier, from southwestern Persia, plants of the natural order *Umbelliferae*.

The resin is found in nearly all parts of the plant, in large schizogenous channels in the outer cortex, but is obtained from the stems and sometimes from the bases

of the leaves as a simple exudate. As a rule, no single method of collection is followed, but similar methods to those practised for collecting asafoetida may be employed. Freshly exuded galbanum dries into tear-like masses if undisturbed. These sorts constitute the better varieties. If the exudate runs together, masses are formed; these may be commingled with bits or slices of the stem, indicating hasty collection.

Description.—When in a fresh state, the resin is a fluid, milk white, but by oxidation becomes yellowish and thick, finally becoming hard. In the market it may generally be found in irregularly aggregated grains from 0.5 to 1.5 cm. in average diameter, externally light to dark brown, lighter within, at times whitish to bluish green. The grains are soft and break readily with an irregular fracture. Some samples come into the market with a large percentage of oil, which renders them somewhat viscid. The taste is sharp, somewhat aromatic and bitter. The odor is unpleasant to many people; it is somewhat aromatic.

If a small portion of the resin is placed upon a sieve in a beaker glass with $\text{Ca}(\text{OH})_2$, a sheath of bluish fluorescence can be seen on the surface, the rest of the fluid remaining brownish. A similar reaction, Flückiger states, is seen with asafoetida. Ammonia gives negative results. If galbanum is mixed with hydrochloric acid, specific gravity 1.12, at the end of an hour, sooner upon warming, a brilliant red color is produced.*

Chemistry.—Galbanum is a mixture of varying quantities of ethereal oil, 9.5 per cent., resin, 63 per cent., and gums, 27 per cent.; ash is about 8 per cent.

Galbanum resin is an umbelliferon-galbaresinotannol. Ether breaks it up by KOH into umbelliferon and galbaresinotannol, $\text{C}_{18}\text{H}_{29}\text{O}_2\text{OH}$, which forms a brown amorphous powder.

* Flückiger: Lehrbuch, p. 65.

The oil is transparent and yellowish, specific gravity 0.910 to 0.940, and yields among other products of distillation a sesquiterpene (Cadinene, $C_{15}H_{24}$) between 270° and 280°C. and d-pinene between 160° and 161°C.

AMMONIACUM. AMMONIAC.

Ammoniacum is a gum resin derived from the stems of *Dorema Ammoniacum*, D. Don., a forest plant of Persia. Other species of *Dorema* yield similar products.

The plant has an abundant supply of milky juice which exudes spontaneously and hardens in variously shaped masses. Fine tears, varying in size from 2 to 5 mm. up to the size of a hazelnut, are obtained from insect punctured wounds,* while the so-called ammoniacum amygdaloïdes is obtained from the root of the plant.

The resin is found in special secretory passages similar to those found in asafoetida and galbanum. In ammoniacum they lie in contact with the vessel bundles.

Lump ammoniacum and *Tear* ammoniacum occur in commerce. The former consists of miscellaneous masses of debris of sticks, stones, etc., with pressed together tear-like masses.

Tear ammoniacum is made up of large tear-like granules. These granules vary greatly in size, from small bird-shot to larger nut-shaped masses. They are generally translucent, whitish to yellowish or brownish. Internally they show a waxy lustre in fracture. At ordinary temperatures the granules are wax-like or sticky, sometimes running together in viscid masses. In the cold the ammoniacum is brittle. The taste is sharp and bitter, later aromatic. The odor is peculiar and aromatic, distinct from galbanum, but by no means as unpleasant as that of asafoetida.

Microscopical.—Under the microscope ammoniacum shows as a gummy, homogeneous ground mass in which small kernels and droplets are intermingled. Small

* Hart: Tr. Linnaean Society XVI, 1833, p. 605.

splinters of resin may be seen which show irregular and finely-toothed edges. On the addition of water the gummy ground mass is dissolved; the granules and droplets forming emulsions.

Chemistry.—Ammoniacum consists of a mixture of varying proportions of ethereal oils, 1 to 2 per cent., resins, gums, 65 to 70 per cent., and pectin-like bodies. Ash 20 per cent. A certain amount of water is always found in the commercial product.

The ethereal oils are found in small quantities only, generally less than 10 per cent. It is soluble in CS_2 . The resin is to be distinguished from other resins, according to Pflugge,* in that its alcoholic solution gives a red reaction when added to a bromide of sodium solution (30 gr. NaOH in Aq. Br. 20 gr. Aq. 1 liter). Umbelliferon would seem to be absent.

MYRRHA. MYRRH.

Myrrha is a gum resin obtained from *Commiphora Myrrha* (Nees), Engler, a small tree native of Arabia and the northeast coast of Africa, where, however, a number of allied species are to be found.

Myrrh flows spontaneously from the bark, being an emulsion-like fluid, and is formed in the inner bark in schizogenous passages, there lying amid parenchymatic secretory cells.

As the myrrh first exudes, it is soft and yellowish, clear or turbid, becoming as it hardens more golden and clear, finally golden yellow to reddish. In the market it appears as irregular, angular lumps, made up of a number of smaller lumps or tears, the surface being irregular and rough, yellowish to reddish, translucent, yellow, waxy. The fracture is also waxy and the cut surface is of the same color or darker, even brown, or specked with lighter pieces, some white. Very hard pieces have a

* Archiv d. Phar., 221, 1883, p. 21.

splintery fracture, small pieces of the splinters being transparent.

Myrrh powders with difficulty. Rubbed up with water it produces an emulsion which shows globules of oil, resin, and pieces of bark.

The odor is agreeable and characteristic. It can be chewed and the taste is aromatic, later bitter to acrid.

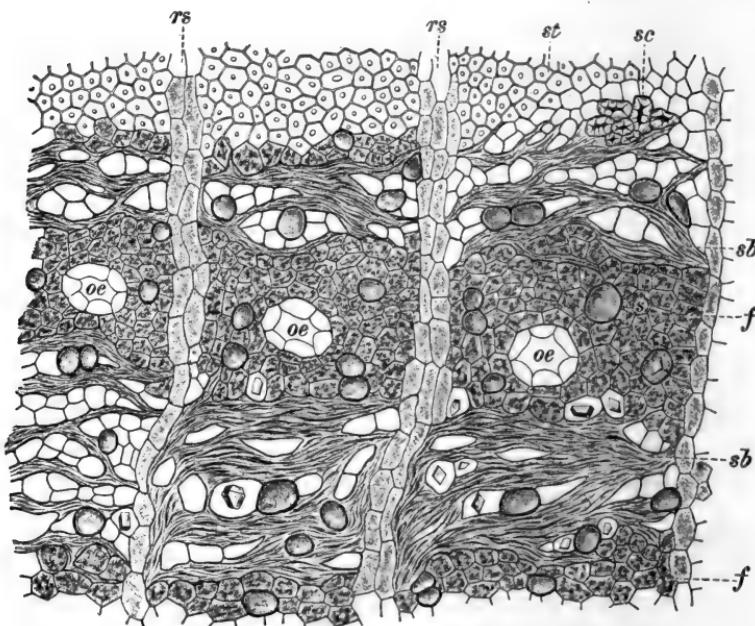


FIG. 7.—MYRRHA.

Cross-section of bark of *Balsamea Myrrha*: *sb*, Obliterated sieve tubes; *st*, bast-fibers; *f*, *s*, coloring-matter and secretory cells; *oe*, oil and resin passages; *rs*, medullary rays; *sc*, stone cells (Tschorch).

Dark colored pieces, and more particularly those that are soluble in water, should be rejected.

Chemistry.—In alcohol and ordinary solvents myrrh is but slightly soluble. In hot water it gives up a bitter principle, and from 40 to 60 per cent. of gum. In addition it also contains 4 to 5 per cent. ethereal oil and 25 to 30 per cent. resin; soluble in alcohol, which solution

gives a violet reaction with HNO_3 . Ash 3 to 4 per cent.

The ethereal oil, *myrrhol*, is clear yellow in color, thin, and soluble in alcohol and ether. It boils at 266° F., specific gravity 1.0159 acid.

In the markets, Turkish, African, and Indian myrrh are to be distinguished. The former is thought to be the best gum, being the clearest. The African resembles it closely, with fewer whitish lines or pieces. The Indian is the darkest and the most impure.

There are many other types of myrrh found in the market.

STYRAX. LIQUIDAMBER. STORAX.

Styrax is a balsam prepared from the inner bark of *Liquidamber orientalis*, Miller. The European plant is a member of the *Hamamelideæ* and is a native of Asia Minor and Syria. The American liquidamber, *Liquidamber styraciflua*, is a closely allied species.

The balsam is found in passages pathologically induced in different parts of the trunk and stems, but does not seem to be found as accompanying any kind of tissue. It is found most plentifully in the phloem portion of the old stems, but apparently only after an injury done to the tissues. After such injury the balsam passages are found among the woody fibers, at first of schizogenetic origin, later lysigenous.

The balsam is obtained generally from the bark by heating it in warm water in large receptacles; often sea water is used. (Flückiger.) The balsam is collected from the water and the bark is then pressed and used for a variety of purposes.

Description.—Styrax is a thick, tough, opaque, semi-solid, sticky opaque mass, with a grayish to gray brownish color. On standing it deposits a heavier brown stratum. It is transparent in thin layers and has an agreeable odor and a balsamic taste. The purified drug

is insoluble in water but soluble completely in an equal weight of warm alcohol. The crude drug has from 15 to 20 per cent. of organic detritus, the main elements of which are readily distinguishable under the microscope.

Chemistry.—The main constituents of styrax consist of cinnamic acid esters of various alcohols. According to Fehling,* the following is the composition of styrax:

Styracin	5 to 10	per cent.
Phenylpropyl cinnamate	10	"
Cinnamic acid, Storesinester	10 to 20	"
Alpha Beta Storesin	50	"
Cinnamic acid	2 to 5	"
Styrol	2 to 3	"
Vanillin	0.5	"

According to Miller,† the American styrax contains styracin and phenylpropyl cinnamate, whereas the ethyl and benzyl ester cinnamates are lacking.

* Neues Handwörterbuch der Chemie VI, 1898, p. 1375.

† Liebig's Annalen, 220, 1882, p. 648.

DRUGS OF VEGETABLE ORIGIN WITH ORGANIC STRUCTURE.

POWDERED SUBSTANCES.

STARCHES.

Starch is one of the most widely distributed of plant products, being found in some of its many forms or modifications in nearly all families of the plant world.

For the pharmacognocist a knowledge of the starches is one of the most useful helps in the examination of drug and food products. It is for him essential to know the more common starches, and in the official drugs so many of the starch forms are so constant that they are diagnostic. The starches of the various roots and rhizomes will be noted under their appropriate heads, and it here remains to note some of the more important starches used as such.

Starch for present purposes consists of small grains, irregular in shape, possessing certain characteristics. The intimate structure of these grains is a matter still in controversy.

For the present the starch grain is supposed to have commenced at some definite point, spoken of in technical language as the "hilum." About the hilum the starch grain has grown up — how, we do not venture to assert — until it comes to possess a more or less definite shape and size. The points in morphology to be noted are: shape, whether the grains are bounded by rounded or angular surfaces; size; grouping, whether the grains are single (simple) or arranged in groups (compound); presence or absence of a hilum; position of the hilum, in the centre, centric, or to one side, eccentric; shape of the

hilum, whether a point, a line, or a star-shaped figure, etc.; finally, the presence or absence of markings, the so-called concentric annulations which are brought out most sharply by the polariscope.

In the higher plants two main types are to be distinguished: Assimilated Starch and Reserve Starch. The latter is partly starch of assimilation which has been dissolved and has passed through the leaves and into the bark, where, passing from cell to cell, it is called transitory starch and is often in small grains 2 to 5 microns in diameter. From here it passes on and is found stored up in roots, stems, tubers, and seeds to serve as a reserve food-product. It is in this process of making the reserve starch that the activity of many of the leucoplastids is apparent, though reserve starch may perhaps be made without them. This reserve starch is generally in larger sized grains, which may measure from 30 to 200 μ in diameter.*

Starch grains vary widely in shape and size, being roundish, elliptical, or ovate. Their edges may be rounded. They may be angular, simple, made of individual grains or sometimes crowded together as a compound grain with many-sided granules. At times their structure appears perfectly homogeneous, again they are distinctly laminated. In many grains there is a point, the *hilum*, which is in the centre, centric, or to one side, eccentric, around which these lamellæ are arranged in concentric rings. Sometimes the hilæ are more than one, in which case a compound grain is formed. (Fig. 8.)

Both the physical and chemical structure of the starch grain is imperfectly understood. It was at one time held that the starch grain was made up of two different bodies, starch cellulose (also called amylodextrin) and granulose, the former staining yellow with iodine, the latter blue. A later view has been that starch cellulose

* A. Meyer: Die Stärkekörner, 1895.

is not normally present, but is the product of a diastatic ferment of some type, and that the starch grain is made up of granulose,* the lamellated appearance being due to alternating variations in the watery content of the granulose. This view of Nägeli's has been taught for years, but there seem to be objections to it.

In the practical identification of many vegetable products starch-grains are the most important structural elements, and a key to the identification of the common starches in daily use is of service in the diagnosis of adulterations.

When examining specimens containing starch it is advised to examine the specimen first in water, then bring to the edge of the cover-glass a drop of strong alcohol. This produces a streaming of the fluids under the cover-glass, rolls the specimens about somewhat, and thus gives a view of all sides of the starch grains.

In certain drugs, such as Curcuma, Jalap, etc., the heat used in the curing of the specimen often modifies the shape of the starch grains.

Classification.—There are numerous classifications of starch grains; the most important of these are to be found in Wiesner, "Mikroskopische Technologie," and in Nägeli, "Stärkekörner." The classification of Vogl is here given for reference.

A. Granules simple, bounded by rounded surfaces.

I. Hilum central, layers concentric.

a. Mostly rounded or from the side, lens-shaped.

* For the latest and best résumé see Meyer, *Die Stärkekörner*.



FIG. 8.—STARCH GRAINS OF POTATO (Sachs).

- 1. Large granules, $0.0396-0.0528$ mm. Rye starch.
- 2. Large granules, $0.0352-0.0396$ mm. Wheat starch.
- 3. Large granules, 0.0264 mm. Barley starch.
- b. Egg-shaped, oval, kidney-shaped. Hilum often long and ragged.
 - 1. Large granules, $0.032-0.097$ mm. Leguminous starches.
- II. Hilum eccentric, layers plainly eccentric or meniscus shaped.
 - a. Granules not at all or only slightly flattened.
 - 1. Hilum mostly at the smaller end, $0.06-0.010$ mm. Potato starch.
 - 2. Hilum mostly at the broader end, or toward the middle in simple granules, $0.022-0.060$ mm. Maranta starch.
 - b. Granules more or less strongly flattened.
 - 1. Many drawn out to a short point at one end.
 - a. At the most 0.060 mm. long. Curcuma starch.
 - b. As much as 0.132 mm. long. Canna starch.
 - 2. Many lengthened to bean-shaped, disk-shaped or flattened; hilum near the broader end, $0.044-0.075$ mm. Banana starch.
 - 3. Many strongly kidney-shaped; hilum near the edge, $0.048-0.056$. Sisyrinchium starch.
 - 4. Egg-shaped; at one end reduced to a wedge, at the other enlarged; hilum at the smaller end, $0.05-0.07$ mm. Yam starch.
- B. Granules simple or compound, single granules or parts of granules, either bounded entirely by plane surfaces, many angled, or by partly rounded surfaces.
- I. Granules entirely angular.

1. With a prominent hilum. At most 0.0066 mm. Rice starch.
2. Without a hilum. The largest 0.0088 mm. Millet starch.

II. Among the many angled, also rounded forms.

- a. Few partly rounded forms present, angular form predominating.

 1. Without hilum or depression, very small, 0.0044 mm. Oat starch.
 2. With hilum or depression, 0.0132–0.0220 mm.
 - a. Hilum or its depression considerably rounded; here and there the granules united into differently formed groups. Buckwheat starch.
 - b. Hilum mostly radiatory or star-shaped; all the granules free. Corn starch.
 - b. More or less numerous kettledrum and sugar-loaf-like forms.

 1. Very numerous eccentric layers; the largest granules 0.022–0.0352 mm. Batata starch.
 2. Without layers or rings, 0.008–0.032 mm.
 - a. In the kettledrum-shaped granules the hilum depression mostly widened on the flattened side, 0.008–0.022 mm. Cassava starch.
 - b. Depression wanting or not enlarged.
 - aa. Hilum small, eccentric, 0.008–0.016 mm. Pachyrhizus starch.
 - bb. Hilum small, central or wanting.
 - aaa. Many irregular forms, 0.008–0.0176 mm. Sechium starch.
 - bbb. But few angular forms; some with radiatory hilum fissure, 0.008–0.0176 mm. Castanospermum starch.

C. Granules simple and compound, predominant forms

egg-shaped and oval, with eccentric hilum and numerous layers, the compound granules made up of a large granule and one or more relatively small kettledrum-shaped ones, 0.025–0.066 mm. Sago starch.

LYCOPODIUM.

The spores of *Lycopodium clavatum*, L., and of other species of *Lycopodium*, found in Europe, Asia, and North America, in dry woods.

Description.—Pure lycopodium forms a yellow, very mobile powder, which floats upon water and is rapidly ignited when thrown into a flame. Examined under the microscope, it is composed of spores 25 microns in diameter, of the shape of a triangular pyramid with convex base. The entire surface of the spore is covered by a delicate network of projecting ridges. When crushed, the spores burst and drops of yellow oil exude.

Chemistry.—The chief constituents are 20 to 47 per cent. fatty oil, a volatile alkaloid, and 4 per cent. ash.

Adulterants.—Lycopodium is frequently adulterated with starch, inorganic substances, sulphur, and pollen of coniferous trees. The appearance under the microscope is so characteristic that sophistication can readily be detected.

LUPULINUM.

Lupulinum consists of the glands obtained from the strobiles of *Humulus Lupulus*, L., a plant of the north temperate zone.

Description.—Under the microscope, lupulinum is seen to consist of spherical bodies, containing two distinct halves. The lower portion is made up of small, flat, polygonal cells, the upper is a raised, homogeneous cuticle. The full-sized gland measures 250 microns in diameter, but will vary considerably in size and shape if the contents are less

in amount. Contamination is very common and can easily be detected.

Chemistry.—Lupulinum contains wax, 2 per cent. eth-

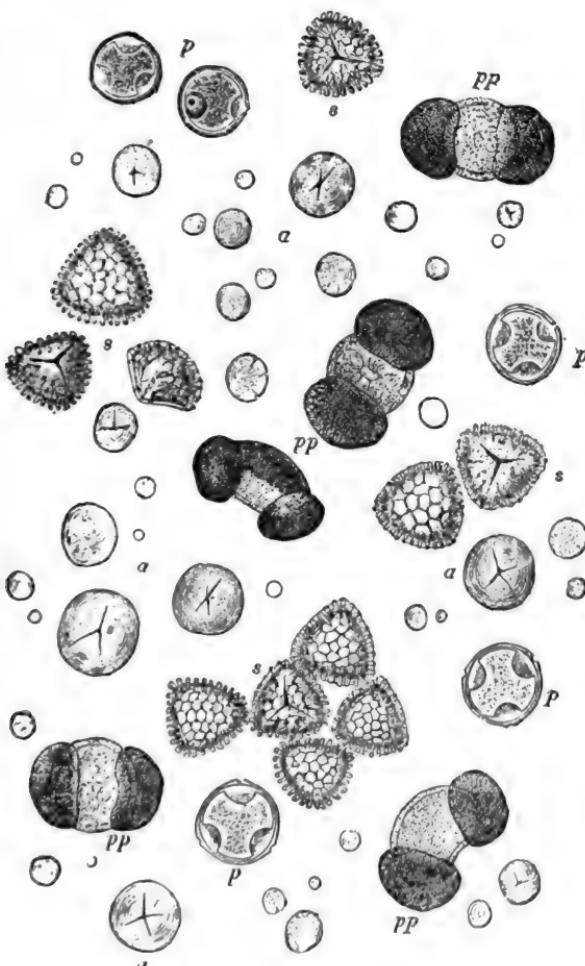


FIG. 9.—LYCOPodium.

s, *Lycopodium*, adulterated with *p*, pollen of *corylus*; *pp*, pine pollen; *a*, wheat starch.

real oil, 3 per cent. glucose, and 0.1 per cent. of resin and bitter substance. Two alkaloids have been described.

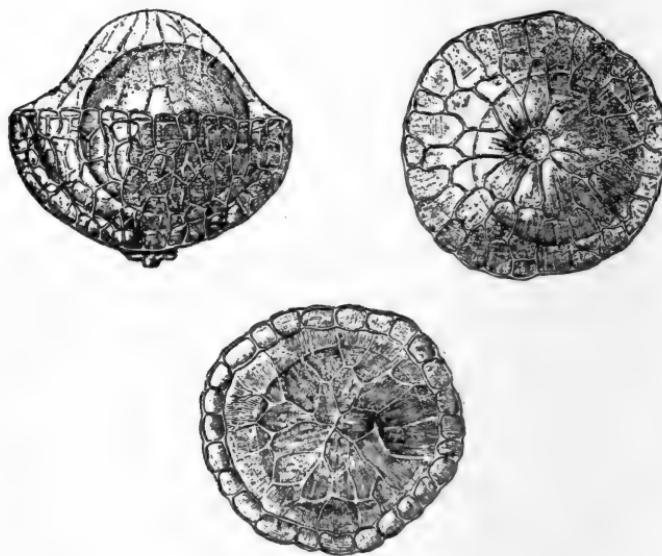


FIG. 10.—*LUPULINUM*.
Glands seen from different sides.

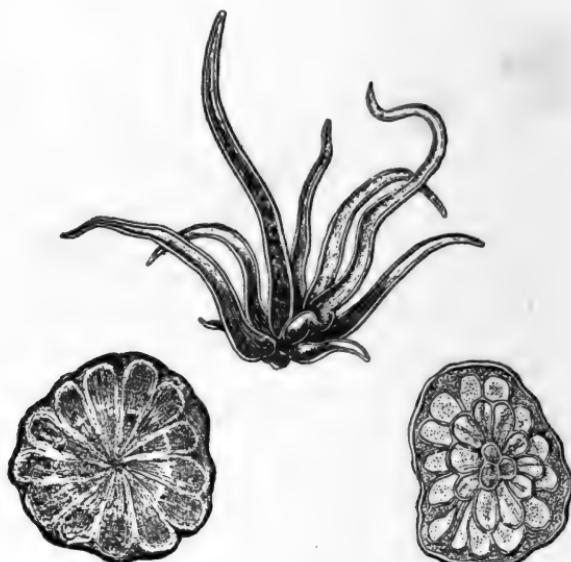


FIG. 11.—*KAMALA*.
Glands and hairs.

KAMALA.

Kamala consists of the glands and hairs that cover the fruit of *Mallotus Philippensis*, a small tree of India and neighboring countries. The tree produces capsular fruits the size of a pea. These are completely covered by a red powder, which is simply shaken off.

Examined under the microscope, kamala will be seen to consist of glands and hairs. The former are smaller than lupulinum glands, possess a depressed, globular shape, are filled with a red resin, and contain a number of club-shaped secreting cells radiating from a common centre. The hairs are thick-walled, curved, and are usually arranged in small groups.

Chemistry.—The resin of kamala has been separated into six different principles:rottlerin, isorottlerin, two resins, wax, and a yellow pigment.

GALLA. GALLS.

An excrescence on *Quercus lusitanica* and other species of oak, caused by the puncture and ova of *Cynips gallæ tinctoria*.

These are produced by the female insect, who deposits her egg or eggs in a rapidly growing part of the plant, where, by the irritation produced, the tissues of the plant take on an abnormal and rapid growth, providing for the larvæ a place of refuge against foreign enemies and also providing for them a store of food (the deposit of tannin seeming to be an added means of protection to the insect*).

After the larva has matured, it bores its way out of the gall and goes on to complete its development outside. (Unbored galls are preferred.) Up to the time of the escape of the insect the gall is usually greenish; after that it is apt to turn brown.

* Adler: Deutsche entomolog. Zeitsch., 1887, 305, 352.

The following varieties are common: (1) Aleppo; (2) Chinese galls.

Aleppo Gall.—A small, circular, greenish gall, having a diameter of about 3 cm. It comes into the market under a variety of names according to the provinces from which it is derived—Smyrna, Tripoli, etc.

They are somewhat shiny in their outer appearance, short-stalked, and on the upper side often rendered irregular by sharp-pointed warts or excrescences. The under side is smooth.

The younger sorts are darker, greenish; the older sorts are apt to be brown, reddish yellow, and hence, dark and light, or black and white galls. The former sink in water, the latter generally float. The point of departure of the insect is generally on the under side of the gall. If the larva has not developed, the gall, when cracked, is found to be full of loose parenchymatic tissue, while if the larva has escaped, the gall is empty in the centre save for the webby remains of the insect's eating—sawdust.

Some degree of variation is to be noted in different examples of the same type of galls under the low power, but in the main the following regions can be made out: The centre (5 to 7 mm.) is hollow, or if the larva has only partly matured the centre is filled with loose, small-celled, starch-filled cells (40μ), starch in thick masses, and round tannin masses. On the outer border of what may be called the insect chamber is a thin sheath that separates this starch-bearing parenchyma from the outer gall. This sheath, perhaps one-half the diameter of the gall, is composed of yellowish stone cells, whose walls are thickened. The tissue of the outer gall is mainly parenchymatic, loosely thickened by spiral cell structures, richly pored in the inside layer. Primary vessel bundles may run through the long diameter from the centre. These are mainly composed of spiral vessels,

with a few sieve-tube-like cells. Numerous crystals of calcium oxalate of both rhomboid and agglomerated types are found and the cell walls are nearly all thickened by rich deposits of tannin. The outermost cells are smaller and have thickened walls.

Chemistry.—Tannic acid up to 70 per cent. of the best galls; sugar, 3 per cent.

Chinese and Japanese Galls.—These are produced on the young twigs of a species of Sumac, *Rhus semialata*, indigenous to northern and northwestern India and the Himalaya chain, and also in related species. The insects deposit large numbers of eggs and would hatch a large brood. In collecting, the eggs or larvae are killed, generally by the application of steam.

In general the galls may be said to be very irregularly egg-shaped, but all sorts of shapes are to be met with, the galls being bladdery with irregular projections and knobs, and twistings and contortions.

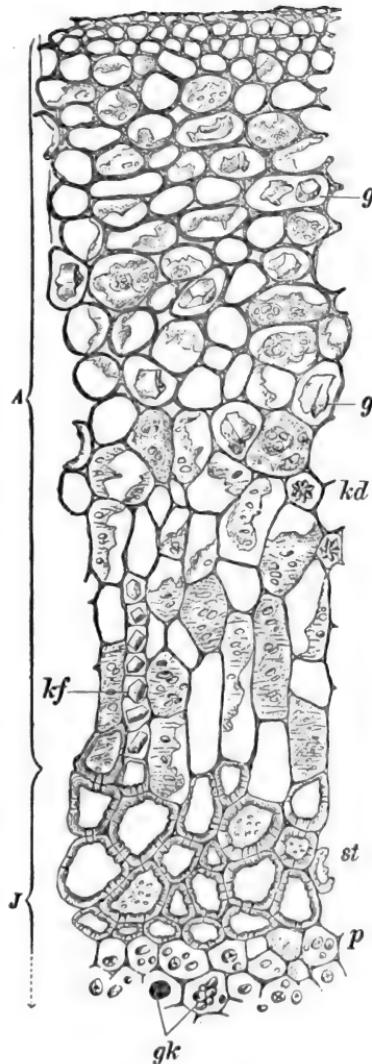


FIG. 12.—GALLA.

Cross-section of an Aleppo gall: A, Outer portion of gall; J, inner portion; g, tannic acid and masses; kd, crystal sacs; kf, isolated crystals; st, stone-cells; p, parenchyma; gk, starch (Moeller).

In general they run in size

from 5 to 8 cm. in length, and $2\frac{1}{2}$ to 4 cm. in width. The thickness of the rind is from 2 to 8 mm.

The color is grayish-brown, sometimes having a soft brown bloom, which on being rubbed off reveals the more or less translucent brown shell of the gall beneath.

The fracture is horny or splintery and the internal surface is smooth and generally lighter in color than the outside. In the interior, products of insect life may be found. The Japanese galls are usually smaller.

Microscopical Characteristics.—An inner and an outer epidermis-like arrangement of cubical parenchyma cells is to be noted; those on the outer wall having outgrowths of short one- to two-celled simple hairs. The centre of the rind is made up of parenchymatic cells which, from without inward, are at first tangentially arranged, and later grow larger, irregular, and mesh-like in disposition, while here and there are to be observed simple vessel bundles, made up of a few small spiral vessels and one or two small sieve tubes and sometimes milk (?) tubes.

The cells of the inner region are cubical, somewhat like those of the outer wall, but may be arranged in but one or two layers. The parenchymatic cells contain irregular masses of tannic acid and a number of green circular bodies and small starch grains.

Chemistry.—Tannic acid in large quantities; gallic acid, fat, resin, ash, 2 per cent.

Other Galls.—A large number of other types of galls are used commercially, some of the most important being:

(a) Hungarian Galls, derived from *Quercus sessili-flora*, and pedunculated, by means of insect, *Cynips leguicola*. Some are small; up to 1.5 cm. in size, reddish brown in color. Again, there are large ones, on *Quercus pedunculata* by means of *Cynips Hungarica*. These are grayish or brownish, circular, 3.5 to 5 cm. in diameter, with irregular warty surfaces.

(b) German, Bohemian, and French Galls from different species of oak, produced by *Cynips Kallari*, present certain variations. In general they are small circular galls, 1 to 3 cm. in diameter, light brown in color, generally smooth or with scaly epidermis, rarely warty.

(c) Various American species of oak give galls,—*Quercus alba* and *bicolor*, *obtusifolia*, *virens*, *lobata*, etc. These present a variety of aspects and are used locally in the manufacture of tannic acid.

PLANT ORGANS OR PARTS OF PLANTS.

ROOTS.

General Structure of the Root.—For the purpose of the present study the root may be considered as the descending portion of the plant, and is provided with neither leaves nor reproductive members. It is to be borne in mind that all roots are not underground, nor are all the subterranean parts of plants roots. Thus there are a number of plants with aerial roots, and still more numerous are those plants with stems that are underground and which serve some of the functions of roots.

The function of the root may be threefold: It may serve the purpose of support, holding the plant to the earth and giving it its proper foundation; it may serve the purpose of taking in food, usually water holding inorganic salts in solution; or it may serve the purpose of storing the food for the plant. Some roots serve all, others only one or two of these functions.

The study of the general shape, size, and characters of roots belongs to the study of plant morphology and will not be taken up in this volume.* For the purposes of plant anatomy two types of root structure are to be recognized, Primary and Secondary.

Primary Structures.—In the drugs of the U. S. Pharmacopœia there are but few roots showing primary structures. In such, as in the young side roots of *Aristolochia* and *Veratrum viride*, two fairly well differentiated portions may be distinguished, the central part or central cylinder (Stele), and the cortex (Extrastelar part).

The cortex is usually provided with a layer of flattened

* Consult Rusby and Jelliffe: *Morphology and Histology of Plants.*

cells on the outside, the Epidermis, which may or may not be supplied with hairs. The walls are usually slightly thickened and stained dark brown, owing to the process of suberization. Beneath the layer of cells constituting the epidermis are to be found several layers of irregular parenchymatic cells, the Cortex, the outer cells of which abut on the epidermis; in some cases they are thickened and form a special layer or layers, the Hypodermis. The parenchyma of the cortex is frequently filled with starch and often contains cells which contain crystal sacs. Toward the periphery the cells of the cortical portion are more or less regularly arranged, but toward the centre they become more irregular. The innermost layer of the cortical portion is often differentiated into a distinct layer of regularly arranged cells. It is then termed the Endodermis, and serves a number of purposes. Its cells are often characteristic and diagnostic, very frequently the walls become peculiarly thickened and marked and starch grains are found in their cavities.

The central cylinder (Intrastelar Tissue) varies widely in the different roots. It is in this portion of the roots that the differences between primary and secondary structures are most prominent. The layer of cells just beneath the endodermis is usually distinct from the rest of the central cylinder. It is termed the Pericycle or the Pericambium, and consists of thin-walled parenchymatic cells. Inside are the vascular tissues or rudimentary fibro-vascular bundles. These, in most of the roots studied by the pharmacognocist, are arranged in a radial manner, the conjunctive tissue being about them, and in the center forming the pith. In some cases the fibrous portion of the bundles occupies the center (*Veratrum viride*). The number of fibro-vascular bundles varies greatly. Many roots are monostelar, but individual variations are constant.

Secondary Structures.—In cryptogams and most mono-

cotyledons little or no change takes place in the roots, but in gymnosperms and dicotyledons a series of changes take place which modify both cortex and central cylinder.

In the cortex the cells of the epidermis become detached and new tissues grow in order to make the outside correspond with the internal growth. A layer of meristematic tissue, the Phellogen, becomes active, and new secondary cortical tissues are formed on the inside and a bark is made on the outside of this layer of growing cells. The bark of roots and stems differs somewhat; this will be touched upon under the subject of barks. Inside the endodermis, a structure which may disappear, a still greater change is taking place in the development of the fibro-vascular bundles. These commence to approximate, new meristematic tissues develop in their interfascicular cambium, the cambium itself becomes more prominent, forming cell groups just inside the pericycle and extending to the bast groups. This, the fascicular cambium, and the cambium which develops between the bundles, the interfascicular cambium, soon join to form a continuous circle, and the cambium ring of dicotyledons and many gymnosperms is thus formed. By means of this cambium new structures are added to the xylem internally and to the phloem externally. The structures of the xylem of the secondary growth are similar in some respects to those of the primary growth, and yet in certain other features they differ; thus there are no spiral vessels formed, as a rule, in the secondary xylem, woody parenchyma is commonly formed and the tracheal elements are found.

SARSAPARILLA.

Sarsaparilla is the root of *Smilax officinalis*, Kunth., *Smilax medica*, *Smilax papyracea*, and of other (undetermined) species of *Smilax* (nat. ord. *Liliaceæ*).

The main types in the United States markets are the Jamaica, Honduras, Mexican, and Para sarsaparillas;

though a variety of other kinds are found in various markets.

Description.—The external conditions in brief are as follows: Jamaica sarsaparilla is bearded, reddish in color, ends cut, wound with the same root, and slightly wrinkled.

Honduras is non-bearded, brownish, the ends rounded, wound with same kind of root, and slightly wrinkled.

Mexican is non-bearded, in loose bundles, with the rhizome attached, wound with string of foreign root, deeply wrinkled, and the color varying from yellowish to black (according to the amount of dirt left on the rhizome).

The Para variety occurs in very large bundles, wound with various roots, and the ends cut.

Sarsaparilla root comes into the market in a variety of shapes and sizes. The root is in general long, cylindrical, and thin; being from 1 to 3 metres in length and 2 to 5 mm. in diameter, wrinkled, of various shades from reddish to brown or black from adherent dirt, whitish within, inodorous, and of a mucilaginous, slightly bitterish taste.

Histology.—A cross-section of the root shows the following structures from without inward: Under the low power there can be seen an outer cortical portion, whitish in color and surrounding an inner central portion of about the same color. Cutting demonstrates the fact that the outer cortical portion is soft, while the inner central or vessel portion is hard and resisting. Sharp examination will reveal a yellowish line between the two portions, the endodermis sheath, and also the presence of a pith in the centre of the structure.

With compound microscope of high power the cortex is seen to be made up of at least three distinct types of cells—the epidermal, hypodermal, and cortical cells. The epidermal cells are hair-like and brown. They are frequently lacking. The hypodermal cells are thickened and brownish, and arranged in various rows from 2 to 7,

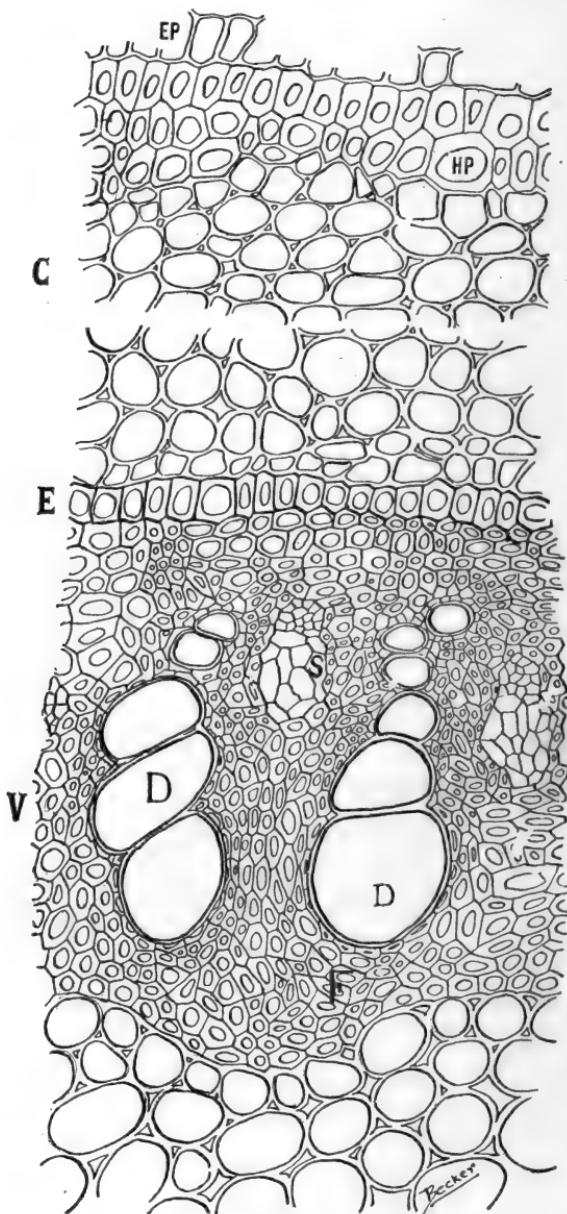


FIG. 13.—CROSS-SECTION OF SARSAPARILLA.

EP, Epidermis; HP, hypodermis; C, cortical parenchyma; E, endodermis; V, vascular portion; D, pitted vessels; F, fibres; S, sieve tubes.

according to the variety of sarsaparilla and the type of soil in which the root grew. The cortical cells are more or less spherical, and contain, in some varieties, numerous starch grains and crystals; in others the starch grains are fewer. The width of the entire cortical layer as compared with the central cylinder is of importance in the diagnosis of the variety.

The cortical layer is separated from the central cylinder by a layer of thick-walled cells, the endodermis sheath, the contour of the cells of which is of much importance.

Inside of the endodermis sheath there is a layer of thin-walled cells, and within this is a cylinder of vessel bundles arranged in a radial manner. The major portion of this cylinder of the vessel bundles is made up of the elements of the xylem, which completely inclose the phloem elements, almost hiding them from sight.

The xylem contains vessels and fibres. The vessels are from 30 to 40 in number and are of the pitted type, the pores being both simple and bordered, and many of the smaller peripheral vessels have spiral markings. The fibres are very numerous and thick-walled; their characters are manifest in the powder.

The phloem consists of small groups of sieve tubes and parenchymatic cells, immersed in the elements of the xylem. These sieve tubes vary widely, those at the periphery being small-lumened; the inner ones are larger, and the sieve plates are exceedingly oblique. Inside of the cylinder of vessels there is a pith which contains elliptical to spherical cells, rich or poor in starch grains. The starch grains are apt to be compound grains of from 2 to 6 granules.

In attempting to separate the different varieties of sarsaparilla the following points are to be borne in mind: Comparative width of the cortical and central portions; shape and number of rows of cells of the hypodermis; shape and size of the endodermis sheath; variation of

width of the woody cylinder and the pith; shape, size, arrangement, and amount of the starch grains. An important point to remember is that all of these characters are variable, however. The circumstances bearing upon the variability are: (1) the time when root is gathered, younger specimens having fewer hypoderm cells, the walls of the fibrous cells are thinner, the endodermis is thinner, etc.; (2) the time of year when collected, the character and the amount of the starch grains varying with the season. The root also varies at different distances from the rhizome; parts nearer the rhizome are uniformly stouter in all of the elements. Great variability of the endodermis is to be accounted for in this manner. The following characters express the average rather than the absolute conditions:

Microscopical Characteristics of Different Varieties.—

In *Honduras sarsaparilla* under low power the cortical and central parts are seen to be about equal in size. Under high power the hypodermis of one or two layers of cells and some root hairs become visible. Just beneath two or three rows of thickened mechanical cells is the cortex proper, consisting of spherical cells with thickened walls having simple pores; these cells are closely packed with starch grains. The endodermis consists of a single row of cells, more or less quadrangular, the wall usually being uniformly thickened or in some parts of the root a little thicker on the inside.

In *Para sarsaparilla* the cortical portion is two or three times as wide as the central portion. The outer hypodermis is five to seven layers in thickness, the outer walls of these cells being slightly thicker than the inner walls. The cortical cells are rich in compound starch grains. The endodermis consists of cells somewhat radially elongated, which cells are thicker on the sides and inner walls, and conspicuously pored. The pith is white and broader than the vessel portion. Starch is copious.

In *Mexican sarsaparilla* the cortical portion is from three to four times as thick as the central portion. The epidermis is quite often present, with root hairs. The hypodermis is three to five layers of cells wide, the outer angles of the cells are thickened; the lumen is small. The cortical cells vary in starch content. The endodermis cells are usually radially elongated, thickened on the sides and inner walls, of small lumen as a rule (though sometimes the lumen is considerable). The pith is broader than the woody ring, poor in starch, and rich in acicular crystals of calcium oxalate.

In *Jamaica sarsaparilla* the cortex is usually half as wide as the central portion. The epidermal hairs are usually more numerous than in other types. The hypodermis is arranged in two or three rows, its cells thickened on the outer wall and usually with small lumen. The cortex cells are poor in starch, and apt to be richly pitted. In the endodermis sheath, the cells are radially elongated, thickened on lateral and inner walls, and pored. The pith is as large as the woody cylinder, also pitted. Starch is scanty.

Powdered Honduras Sarsaparilla.—A mixture of several sarsaparillas is almost impossible to detect, therefore an average powder will be described. The chief microscopical characteristics are starch, crystals, parenchymatic cells, both thick-walled and thin-walled, hairs, endodermis sheath cells, vessels, fibres, and phloem elements.

The starch grains are very numerous, in twos, threes, fours, or even more decompounded; the hilum is usually centric and the edges are rounded. Single grains range from 5 to 15 microns in diameter, the compound grains varying from 12 to 20 microns. The crystals are of the acicular variety of calcium oxalate; they vary in size, but average about 60 to 80 microns in length.

The parenchymatic cells of the hypoderm are thick-

walled, usually tinged with brown or yellow, and have one wall thicker than the other; they are richly pored and do not contain any starch grains. Their average diameter is about 20 to 30 microns, and they run from four to eight times as long as broad; some are much shorter,

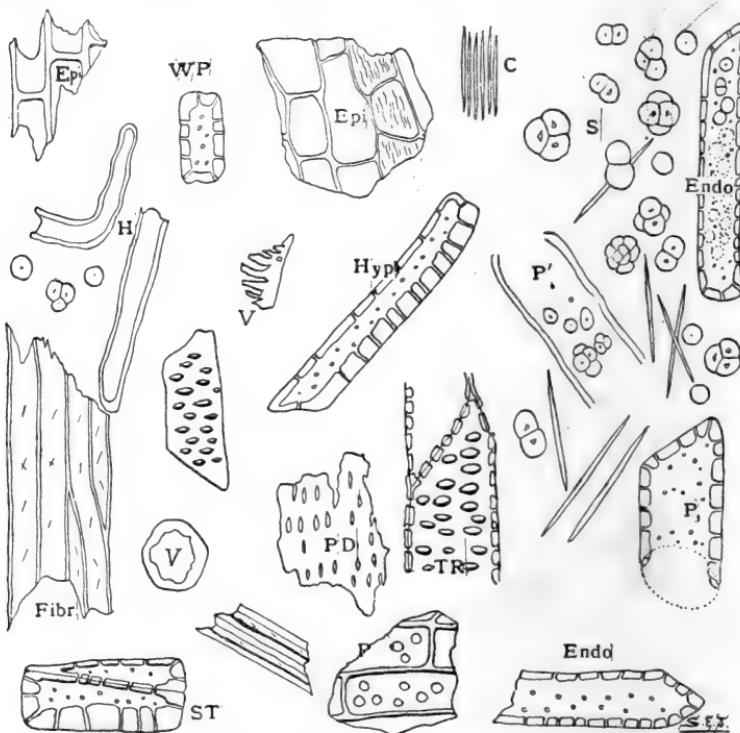


FIG. 14.—POWDERED SARSAPARILLA.

Epi, Epidermis; H, hairs; W. P, wood parenchyma; C, crystals; S, starch; Endo, endodermis; Fibr, fibers; Hyp, hypoderm; P.D., pitted ducts; TR, tracheids; P, P', P., parenchyma; ST, hypoderm stone cells; V, fragments of ducts.

resembling stone cells. The cortical parenchymatic cells are uniformly thinner-walled, though the wall is not very delicate; in general outline they are usually cylindrical, some short, others much longer. The average cross-section of this parenchymatic tissue shows cells whose diameters range from about 50 to 100 microns, the cells nearer the

periphery and those nearer the endodermis being usually the smaller. These cells are uniformly rich in starch. A number of them contain crystals.

The hairs of the root of sarsaparilla, while not a conspicuous part of the powder, yet afford a microscopical character of much diagnostic importance. They are short, irregular hairs with thin brown walls; the general length is about 150 to 200 microns, and their average diameter about 20 microns.

The cells of the endodermis are characteristic, yet in some powders can be differentiated from some of the hypoderm cells only with difficulty. They are thick-walled, richly pitted, and sometimes contain starch grains. Their average diameter is about 20 to 25 microns, and they are usually three to four times as long as broad. The vessels are of the spiral, reticulated, scalariform, and pored types, the pores being both simple and bordered. The diameter of the various ducts ranges from 75 to 250 microns, the largest ones being found near the centre.

Tracheids and cells transitional between tracheids and fibres are common. They range in diameter from 20 to 30 microns. The fibres are present in numbers; they usually average about 20 to 25 microns in diameter, and are not infrequently 200 microns long. Some of the delicate-walled prosenchymatic elements, belonging to the sieve elements, may also be found.

Chemistry.—The chief constituents of sarsaparilla are parillin, by some considered the active principle; saponin, 1 to 3 per cent.; resin, of bitter, acrid taste; starch, 3 to 45 per cent.; crystals of calcium oxalate and traces of a volatile oil. The ash constitutes 3 to 12 per cent.

RADIX BELLADONNÆ. BELLADONNA ROOT.

Belladonna Root is the root of *Atropa Belladonna* (nat. order *Solanaceæ*). Habitat, Central and Southern Europe, in woods.

Description.—The root is cylindrical, somewhat tapering, 1 to 2 cm. thick, grayish-brown externally, deeply furrowed longitudinally, and somewhat transversely above. Fractures smoothly, with discharge of dust; internal surface, white or yellowish-brown. Taste first sweetish, then bitter and acrid.

Histology.—With the lupe a dirty white, mealy cortex is found within the grayish-brown periderm. It is separated from the wood by the cambium, and does not show a radial arrangement. The woody portion of the main root is radially striated at its periphery; in the branches this striation is very fine, and is continued to the centre with interruptions. In the centre itself a large vascular strand is found. Higher powers disclose several layers of brown cork cells in the periderm. The cortex consists of parenchyma cells, with a tangential elongation in the outer part of the section, but more rounded or quadrate internally. They are filled with starch and calcium oxalate crystals. The central portion is made up of alternating xylem bundles and medullary rays, not extending to the centre. The former are broad, and consist of a ground-work of thin-walled cells in which radially arranged groups of vessels are imbedded. The medullary rays consist of amylose parenchymatous cells, which become continuous with the central parenchyma. The centre of the section shows a firm bundle of vessels.

Powder.—The powder of belladonna is usually grayish-brown in color.

The main histological elements found are starch, tracheids, fibres, and cork. Crystal sand forms an inconspicuous element of the powder.

The starch grains are numerous; they are both simple and compound, the compound varieties perhaps about as many as the simple forms. The compound granules exist in twos, threes, occasionally in fours. The average diameter of the simple grains is about 18 microns; individual

grains average from 10 to 30 microns; the compound granules range from 20 to 40 microns in diameter. The hilum is usually centric, naturally somewhat eccentric in

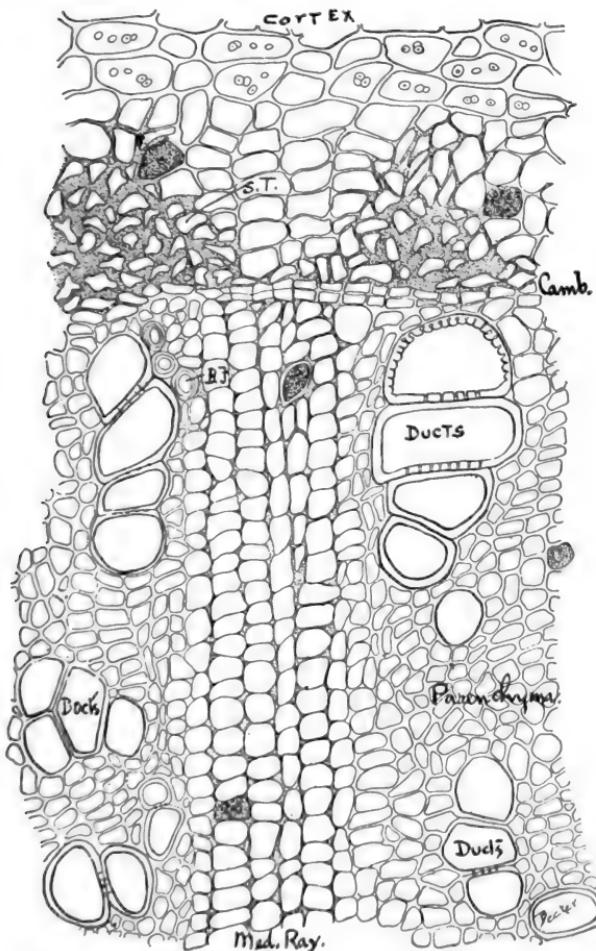


FIG. 15.—CROSS-SECTION OF BELLADONNA ROOT.
S. T., Sieve tubes; B. F., bast fibres.

the compound granules, and is simple or tristellate; the angles of the grain are usually rounded.

There being several kinds of belladonna root in the market, certain variations from the types here described

may be encountered. These express, however, the averages of a large number of examinations.

The ducts of belladonna root are manifest; few spirals are found, and a number of reticulated and pitted forms and varieties with bordered pores; much range in diam-

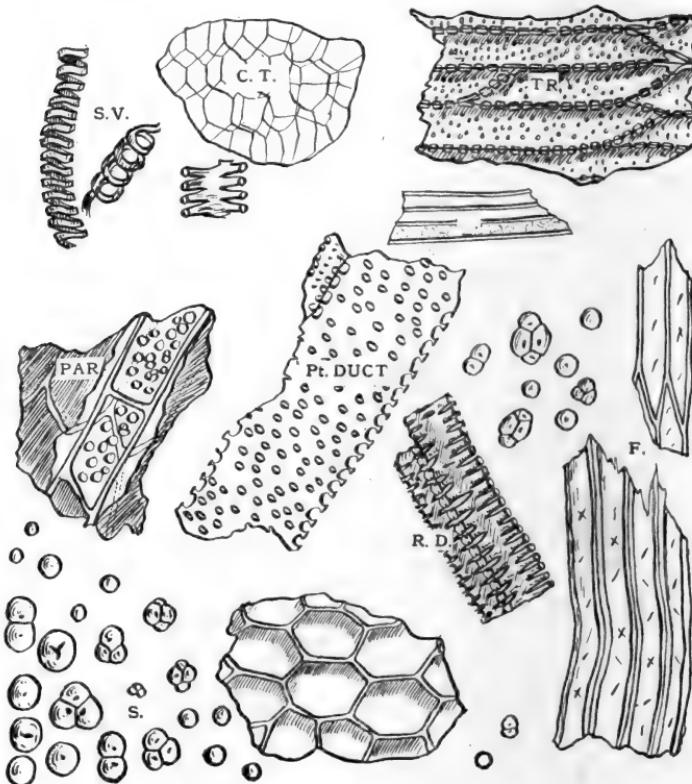


FIG. 16.—BELLADONNA.

S.V., Spiral vessels; C.T., corky tissue; TR., tracheids; PAR., parenchyma; Pt. Duct, pitted duct; S., starch; F., fibres; R.D., reticulated duct.

eter of these ducts is to be observed. The average of several measurements gave: Spiral ducts, 18; reticulated ducts, 25; pored ducts, 40 microns.

The tracheids are typical and prominent; their average diameter is about 30 microns. They frequently are very

heavily pitted and pored. The wood fibres are few, and, as a rule, quite slender; they average 13 microns in diameter.

Parenchyma filled with starch grains is predominant. The cells vary widely in size; they are usually oblong cylindrical, generally being from two to three times as long as broad, and in the main measuring 25 to 60 microns.

Masses of corky tissues, dark and light-brown, are scattered copiously throughout the powder. On clearing the structure of the cells, the walls become manifest. Some few tissues probably derived from the phloem may be encountered with the xantho-proteic test. These tissues give the characteristic proteid reaction for the cell contents. They may be recognized by their delicate walls and the character of their contents.

Chemistry.—The active principle is atropine, which varies from 0.2 to 5 per cent., according to the age of the drug. Other less important ingredients are belladonnae, starch, a red coloring-matter, atrosin, and a substance similar to esculin.

RADIX GLYCYRRHIZÆ. LICORICE ROOT.

Glycyrrhiza is the root of *Glycyrrhiza glabra*, L., and of the variety *glandulifera* (Waldstein et Kittaibel). **Habitat:** Southern Europe and Western Asia; cultivated.

Description.—In long, wrinkled pieces, from 5 to 25 mm. thick, longitudinally wrinkled, externally grayish-brown, warty; internally yellow; pliable, tough, fracture coarsely fibrous, bark thick, wood dense, taste sweet, somewhat acrid. The underground stem, which is often present, has the same appearance, but contains a thin pith. The variety derived from *G. glandulifera* consists usually of roots or root-branches 1 to 4 cm. thick, 15 to 30 cm. long, frequently deprived of the corky layer, the wood soft and usually more or less cleft. Resembling licorice are pyrethrum and taraxacum, but they are not sweet.

Histology.—In the branches a periderm surrounds the thick, yellowish cortex. A cambium line separates this from the thin and angular medullary portion. The bark is radially striated by convoluted bast-fibres and wedge-shaped medullary rays, and the wood by similar woody and medullary rays. The main trunk has the same appearance, except that the medullary portion is missing.

The periderm consists of flat cork-cells in layers, the

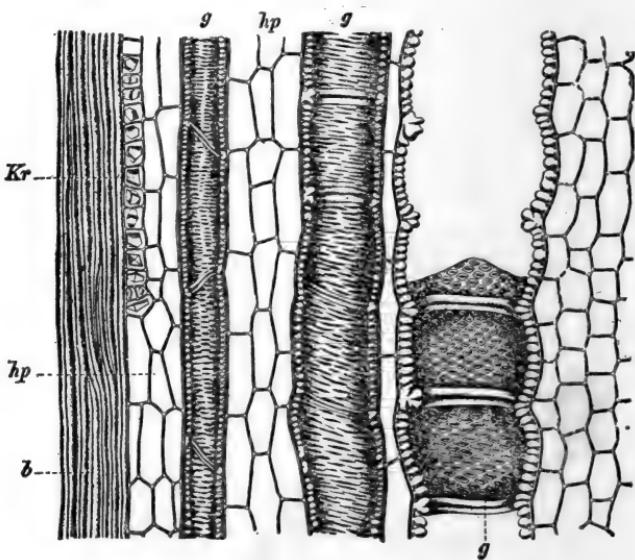


FIG. 17.—LONGITUDINAL SECTION OF GLYCYRRHIZA.
g, Pitted and reticulated vessels, tracheids to left; Kr, crystal sac; b, bast fibres; hp, wood parenchyma.

primary bark of few rows of starch-containing parenchyma cells. The inner bark is much broader and is made up of three- to seven-rowed medullary rays and wedge-shaped bast-fibres. The cells of the medullary rays are tangentially elongated, thin-walled, and filled with starch. The chief mass of the bast rays consists of parenchyma cells with rounded bundles of thickened bast-fibres. The separate bast-fibres have quite a considerable length, and

convoluted course, and in proper section show branchings. A broad cambium line connects the bark with the wood.

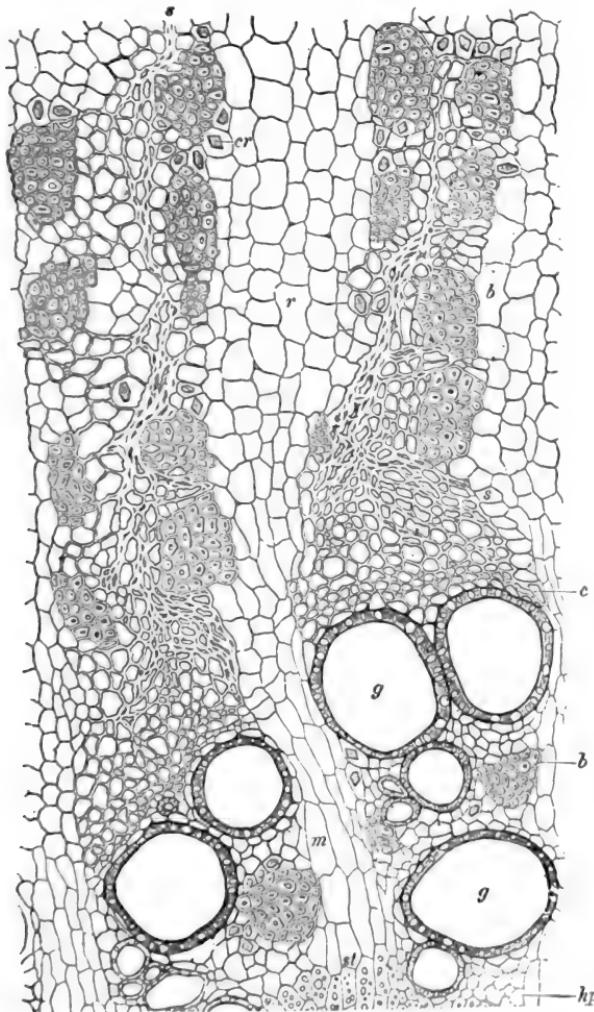


FIG. 18.—CROSS-SECTION OF GLYCYRRHIZA.

b, Bast fibres, wood fibres; *g*, ducts; *m*, medullary rays; *s*, sieve tubes; *hp*, wood parenchyma; *cr*, crystals; *c*, cambium; *St*, starch; *r*, medullary ray in cortex (Tschirch).

The wood rays consist of three tissues. In a ground tissue of thin-walled, woody parenchyma there are wide

or narrow vascular channels, single or in groups of two or four, with spirally thickened or pitted walls. Besides

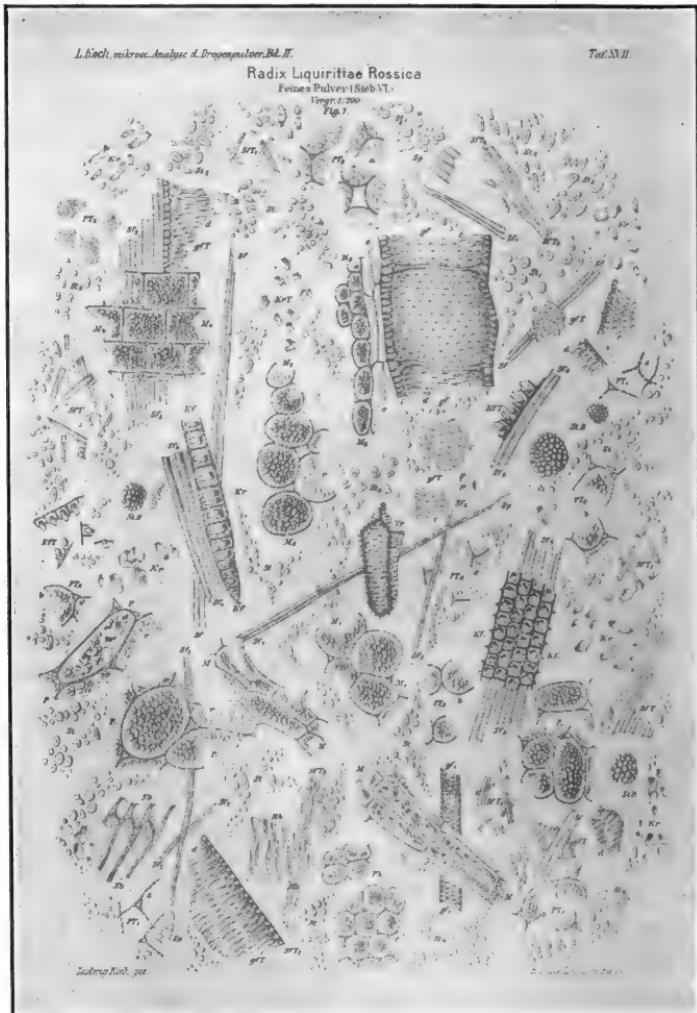


FIG. 19.—POWDERED GLYCYRRHIZA.

P, Parenchyma; *Ph*, phelloderm; *M*, medullary rays; *Sf*, stone cells; *K*, crystal fibres; *Gf*, vessels; *Sb*, sieve tubes; *HC*, keratenchyma; *Kr*, crystals; *St*, starch (Koch).

these there are rounded bundles of thick-walled wood fibres.

Powder.—A medium fine powder, No. 60, is brownish in color, and shows the following elements: Fibres, crystals, vessels, starch, cork cells, and woody parenchyma of medullary rays. The fibres are very numerous. Both bast fibres and wood fibres are accompanied by crystal small sacs, each containing a single crystal of calcium oxalate. A line of such crystals lying along a fibre is a very characteristic picture in licorice powder. The form of the starch grains, cork cells, and medullary ray cells is not of particular diagnostic significance.

Chemistry.—Glycyrrhizin, glucose, mucilage, proteid, starch, tannin, asparagin, fat, resin, and a yellow pigment.

RADIX IPECACUANHÆ. IPECAC.

Ipecac is the root of *Cephaelis Ipecacuanha*, a native of Brazil, and extensively cultivated in India. Two varieties are common in the markets of the United States, the Rio Ipecac and the Carthagena.

The plant grows in deep forests under the shade of trees. The roots are pulled along the ground backwards and then broken off, packed in bags after the dirt, which gives the color to the root, has been cleaned off, then sorted, rapidly dried in the sun and broken into short fragments.

Description.—As the root appears in the market it is in pieces from one to two or three inches in length, twisted, slightly and irregularly contorted, 5 mm. in thickness, grayish to brownish-black, according to the character of the soil, distinctly annulated, annulæ 1 to 1½ mm. apart, wavy in places, longitudinally striated, when dry cracked, the cracks running through the cortex to the central cylinder. The fracture of the cortex is wavy to resinous, that of the central cylinder is short, sharp, and brittle. Odor slight, in the powder nauseous to irritating. The taste of the cortex is bitter, that of the wood less so.

Histology.—Under the dissecting microscope or lupe the cross-section shows a thick cortical portion surrounded

by a thin brownish periderm with a yellowish central woody cylinder. The relative proportion of cortex to central cylinder is an index of the character of the root. Those

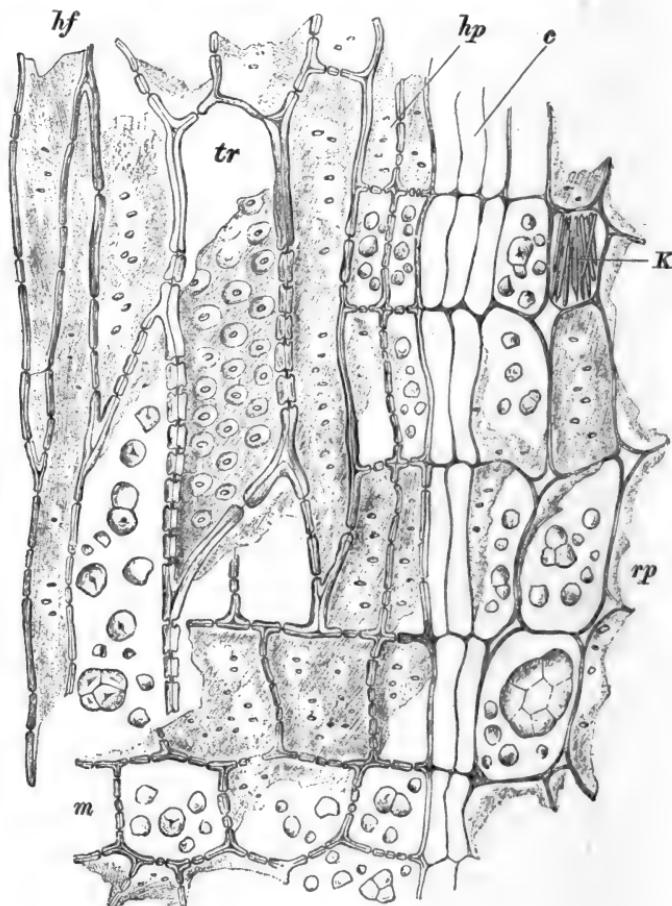


FIG. 20.—IPECAC.

Longitudinal section of Ipecac root: *c*, Cambium; *K*, crystals; *rp*, cortical parenchyma; *hp*, woody parenchyma; *hf*, wood fibres; *m*, medullary rays; *tr*, tracheids with border pores (Moeller).

roots with thicker cortex are considered of better quality than those with thinner cortex, since the active principles are present almost exclusively in the cortex

and, moreover, stemmy ipecac or ipecac stems are made up of thick central cylinders and thin cortex.

With greater magnification the periderm is seen to consist of from four to six rows of regularly arranged cork cells. Beneath this is the cortex, consisting externally of isodiametric polygonal, many-angled parenchymatic cells usually filled with starch, and strongly pitted with simple pores. Here and there throughout the cortex are crystal sacs with larger and smaller bundles of acicular calcium oxalate crystals. The parenchymatic cells of the cortex become more irregular and smaller as the cambium is approached. The fibro-vascular bundles consist of a well-developed xylem and a feebly developed phloem, between which there is the delicate two- or three-layered cambium. The phloem consists almost exclusively of sieve tubes, many of which soon undergo occlusion. These run out into the cortex in thin, irregular, triangular wedges which vary markedly for each bundle. The xylem consists of elements which are difficult of exact definition. They are best termed tracheids, though many transitional forms are found. True vessels in the ordinary sense are missing, and when found in a powder indicate a certain admixture of stem. These tracheids are radially disposed, and are separated by bands of woody parenchyma, though distinct medullary rays are wanting (separating this from *Gillenia*, which also possesses vessels). The individual cells are considered in the powder.

Powder.—The powder (No. 60) is light grayish-brown in color, and has the characteristic penetrating and irritant taste and odor of the drug.

Microscopically, the following elements enter more or less conspicuously into the powder: Starch, crystals, cork, parenchyma, wood fibres, tracheids and vessels.

The starch is the most characteristic feature of the powder, and is almost of diagnostic value alone. The grains are simple, and in twos, threes and occasionally in

fours. The hilum is centric, the margins rounded. In

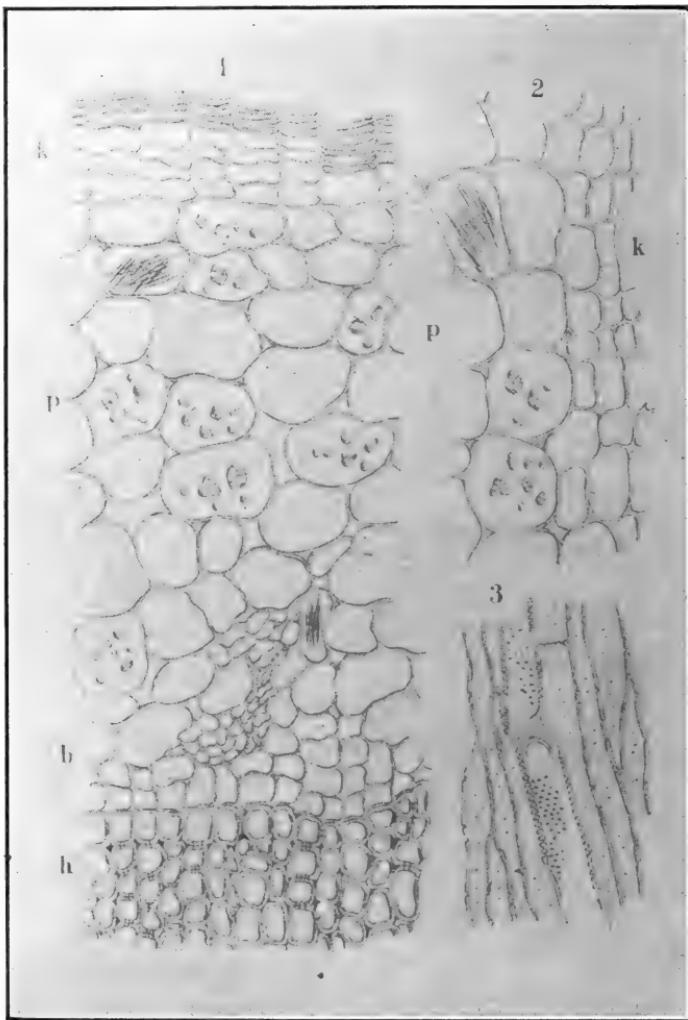


FIG. 21.—SECTIONS OF IPECAUANHA.

1. Cross-section showing corky epidermis: P, Parenchyma, with starch; b, sieve tube groups; h, woody portions made up of tracheids. 2. Parenchyma cut long. 3. Longitudinal section of tracheids (Vogl).

many cases compound granules are observable; in these compound granules the size of the different granules

varies, a point which, according to Tschirch, is of importance. The average diameter of the starch grains is from 7 to 9 microns; some of the larger granules may measure from 17 to 19 microns. Kraemer gives 4 to 7. The smallest are usually about 2 microns. The starch of *Carthagena ipecac* is said to range on the average larger than that of *Rio ipecac*. Schneider's figures are from 17 to 23 microns.

The crystals are of the acicular variety, usually lying in special cells, but in the powder dislodged therefrom they range in length from about 20 to 100 microns, though this only represents an average.

The cork cells are dark brown, and without clearing are usually indistinct in outline; in size the cells range from 9×15 to 15×25 microns.

The parenchymatic cells of the cortex form a large part of the powder. The cells are usually ample, ranging from 60 to 100 microns. They are comparatively thin-walled, and are usually filled with starch grains. Some few special cells of the parenchymatic sheath contain the acicular crystals of calcium oxalate.

The remaining elements of the powder present an interesting series of gradations in cell structure. In some works they are called tracheids, yet there would seem to be enough characters to differentiate wood-fibre like tracheids, true tracheids, and vessel-like tracheids. Schneider describes at least six kinds of tracheids.*

The most characteristic cell forms are: (1) Vessel-like tracheids, having large openings, usually at the end of diagonal cross walls; these are usually the largest tracheids, from 12 to 15 microns in diameter. (2) Tracheids with bordered pores; usually smaller and having no end opening. (3) Ersatzfasern, or wood-fibre-like tracheids, with diagonal pores; these elements are about 15 microns in diameter and about 300 microns long.

* *Journal of Pharmacology*, vol. 4, 1897, p. 3.

True vessels are not found in the root of ipecac, unless the vessel-like tracheids are included under that head; functionally they certainly are vessels and, morphologically, approach them closely. If portions of the rhizome are included in the powder of the root, spiral vessels similar to those figured may be found, also typical stone-like parenchymatic cells, also figured.

Adulterations and Substitutions.—*Undulated Ipecac*.—*Richardsonia scabra* has well-marked medullary rays and spiral vessels. Undulated and wrinkled transversely in the form of shallow constrictions, brownish-gray, bark white, mealy, *not bitter*. The wood is nearly as thick as bark. Microscopically, two round medullary ray rows, vessels, and wood fibres are sufficiently distinctive.

White Ipecac.—From *Ionidium Ipecacuanha*. *Violaceæ*. Somewhat branched, contorted, not annulate, longitudinally wrinkled, whitish or pale brownish-yellow, root porous, free from starch, 2 mm. thick.

In powder, stone cells are found. New cortex also contains sieve tubes. One-rowed medullary rays are also to be found and a few vessels.

Striated Ipecac.—*Psychotria emetica*. Vogl calls it *I. glycyphlæa*. Longitudinally wrinkled, not annulate, 8 microns thick, grayish-brown, sweet, no starch, no emetic. Cortex waxy, inner half of periderm made up of regular cells, tinged with dark violet. These have no starch, but there are numerous crystals of calcium oxalate.

Chemistry.—The chief constituents are emetine, 1 to 2 per cent.; ipecacuanhic acid, an amorphous, bitter glycoside, tannin, volatile oil, starch, gum, etc.

RADIX SENEGÆ. SENEGA.

The root of *Polygala Senega*, from the United States. Two varieties, Minnesota and Manitoba Senega, are generally recognized.

Description.—The root is elongated, sharply triangu-

lar, 10 to 25 cm. long, nearly 0.5 cm. thick, with a swollen warty crown, produced by the remnants of 30 to 40 stems, with reddish scaly leaves. A few tortuous, irregularly contorted branches are given off, generally at right angles. Just below the crown the root is zigzag in outline, twisted about a keel, and sometimes transversely wrinkled. The keel and wrinkles are more prominent in the dry condition. The color of the root is yellowish-gray to brownish-yellow, white within, the fracture sharp and short, the odor and taste acrid.

Histology.—The cortex is light brown, surrounded by a dark periderm, the xylem cylinder white and crossed by narrow medullary rays. Further down, where the keel is well developed, the wood is defective and parenchyma is substituted for it in many places.

Under the microscope the periderm consists of layers of cork tissue. The primary cortex is made up of thin-walled parenchyma cells, which fill out the woody portion where this is defective. Within the keel the inner cortex is well developed and made up of several rows of medullary rays and of bast-fibres. The wood is penetrated by more narrow medullary rays, which resemble those of the inner cortex. The xylem bundles contain wide vessels and the parenchyma cells of the primary and secondary cortex are filled with oil droplets and a pale yellow substance which dissolves in potassium hydrate.

Chemistry.—The chief ingredients are senegin, fatty and ethereal oil, volatile fatty acid, mucilage, tannin, sugar and pectin.

RADIX RHEI. RHUBARB.

Rhubarb is the root of *Rumex officinale*, an herbaceous perennial, growing indigenously in the eastern Asiatic countries. The best specimens are the so-called Chinese.

Description.—In cylindrical or flattened segments deprived of the brown corky layer, covered with a

yellowish powder, smooth or slightly wrinkled, marked with white, elongated meshes, containing a spongy tissue and a number of short, reddish-brown striae; compact, hard, fracture uneven, internally white with numerous red,

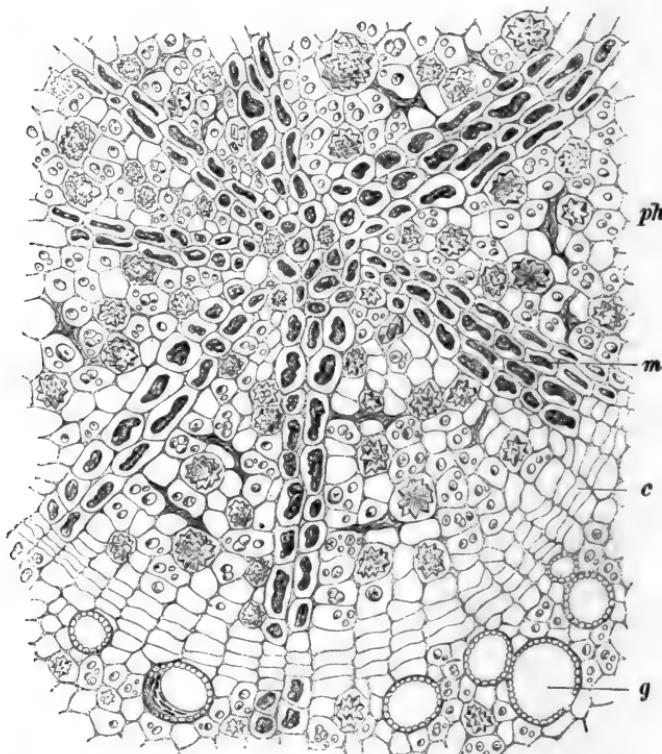


FIG. 22.—RHUBARB.

Cross-section of root portion: *c*, Cambium surrounding a central phloem with medullary rays, *m*, and numerous crystals, obliterated sieve tubes and parenchymatic cells; *g*, vessels; *ph*, parenchyma in phloem. Starch is found in many of the cells.

irregularly curved, and interrupted rays which are radially parallel only near the cambium line; odor aromatic, taste bitter and astringent.

Histology.—When examined with the lupe, large or small remnants of the dark outer cortex are seen.

If only part of the centre is removed, fine, white striae appear upon the surface, which alternate regularly with yellowish-red lines. Where the cortex is removed entirely, the tortuous groups of vascular channels will form a rhombic network. If the woody ring is cut away, the medullary portion will come to view with a number of scattered, circularly arranged rays upon the surface. The granular fracture line shows a meshwork of reddish-brown lines and dark dots upon a white ground substance; a regular arrangement is noticed only with the cylindrical, lateral branches. Here a yellowish-brown cambium line runs parallel and close to the outer circumference; tortuous medullary rays radiate through the parts external to this, to end in a light zone internal to the cambium. The medulla is colored irregularly red and brown and also shows still darker rays without any typical distribution. The whole surface is mottled.

Under the microscope, the white ground-substance consists of thin-walled parenchymatous cells containing starch and calcium oxalate. Every mottling which reaches a diameter of 1 cm. is made up of ten to twenty narrow, dark-brown medullary rays, which run from a central point. The dark line which divides every mottling into two halves consists of cambium tissue. Internal to this cambium, small-celled parenchyma containing starch and calcium oxalate is found between the brown medullary rays; externally tracheids and ring-shaped vascular channels abound. The medullary rays consist of two or three layers of radially elongated cells which are filled with yellowish-brown masses. The red and white mottling of the medulla is due to the presence of these masses or starch.

Powder.—This is reddish to yellow-brown, is gritty between the teeth, and when mixed with water or saliva it imparts to it an orange-red tinge. Microscopically the following elements are usual: Crystals, starch, peculiar

needles of chrysophanic acid (?), parenchyma, vessels, and fibres.

The crystals form the most conspicuous feature in the powder; they are large and numerous, sometimes constituting 30 per cent. of the whole; they are of the rosette type and vary widely in size, measuring up to 100 microns. Some tabular octahedral forms are also observed.

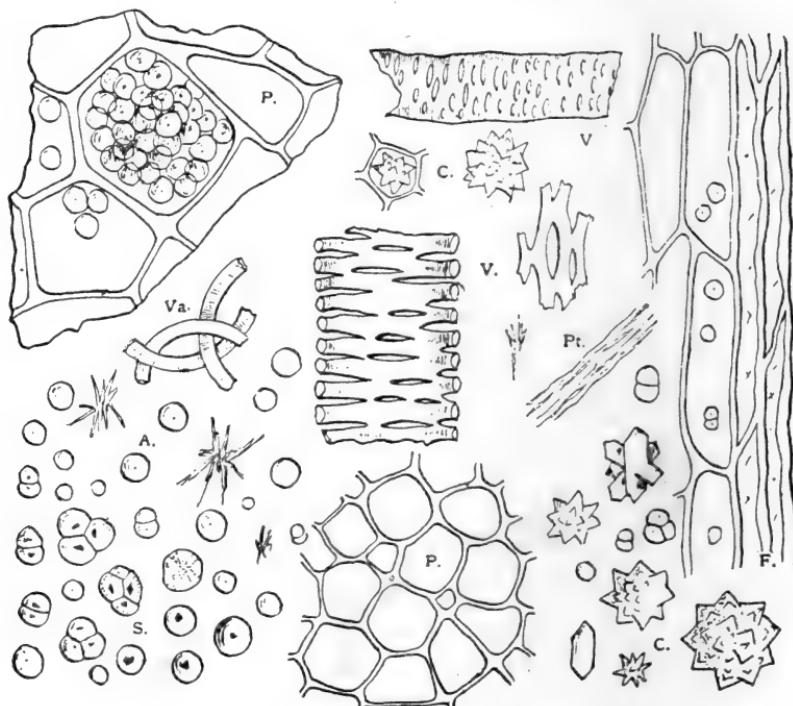


FIG. 23.—RHUBARB IN POWDER.

S, Starch; C, crystals; P, parenchyma; A, chrysophanic acid, crystals (?); Pt, parenchyma, twisted and contorted; V, pitted and reticular vessel fragments; Va, fragments of large vessels; F, fibres.

The starch grains are for the most part simple, though compound grains are not rare. They are spherical to slightly angular and average about 20 to 30 microns. Their polarization cross is conspicuous; the arms are at right angles and attenuate in the centre. Peculiar acicular clus-

ters, deeply stained, are met with in the powder; they are said to be chrysophanic acid. The parenchyma is abundant, very thin-walled, wide-meshed, and usually crowded with starch. Peculiar strings of flattened parenchymatic tissue are frequent.

The vessel fragments are usually large and show the conspicuous reticular markings; sometimes annular and spiral vessels are observed.

The fibres are few and present the characters of short wood fibres, with usually less thickened walls.

Chemistry.—The official rhubarb contains chrysophan, emodin, and the three resinous bodies, aporetin, erythroroetin, and phæoretin; also rheotannic acid, cathartinic acid, a bitter substance, a crystalline body allied to cantharidin, 1.5 per cent. oxalic acid, traces of a volatile oil, and 3.43 per cent. ash.

RADIX GENTIANÆ. GENTIAN.

The root of *Gentiana lutea*, L. (nat. ord. *Gentianæ*), U. S. P. The official gentian is a stately yellow-flowered perennial herb, 2 to 4 feet high, growing in central and southern Europe. The drug is also obtained from several unofficial species, as *G. purpurea*, L., *G. pannonica*, Scopoli, and *G. punctata*, Linné.

Description.—Gentian comes in pieces of about 10 cm. in length and from 1 to 1.5 cm. in thickness, being the entire thickness of the smaller roots and longitudinal slices of the larger. It is sometimes cut obliquely in cross-sections. The heads of the official root are closely annulated, the others scarcely so. In drying it contracts one-third in thickness which causes its contorted appearance and deep longitudinal and spiral wrinkles. The color is outwardly yellow or, from adherent earth, brownish.

The fracture is after a slight bending sharp, showing a golden yellow interior. When cut, it shows a waxy lustre.

The odor is slight, tobacco-like, increased by moistening. Taste very bitter.

Histology.—Microscopically a cross-section of gentian root shows an epidermis of thin-walled cork cells, four to

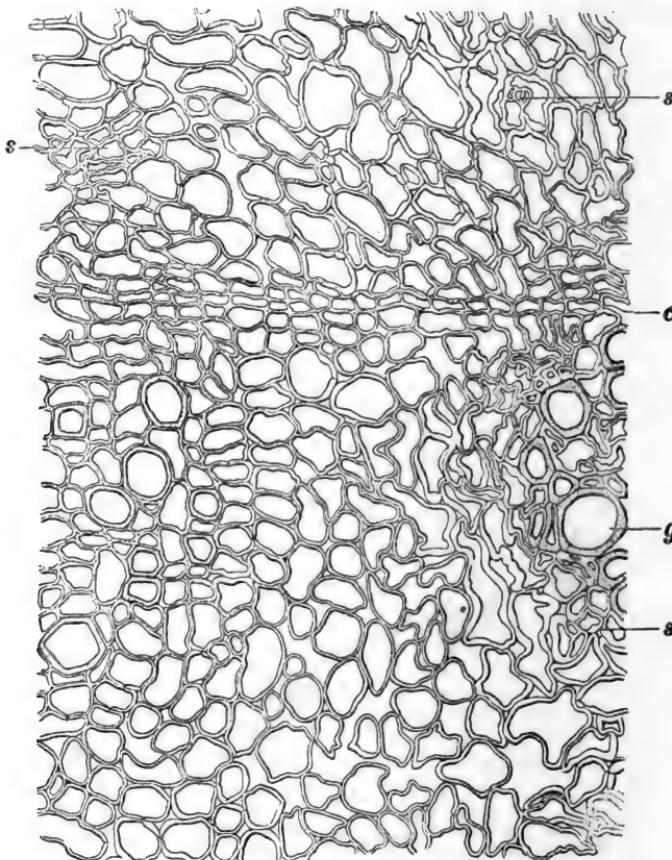


FIG. 24.—GENTIAN.

Cross-section of cambial portion of root of Gentian. *c*, Cambium; *s*, sieve tubes; *g*, vessels with a few fibres, *s*, on the inside of cambium (Tschirch).

eight rows deep, enveloping a narrow zone of weak collenchyma merging into the layer of parenchyma, next within whose loosely arranged tissue are seen occasional sieve bundles but no bast fibres. The dark brown cam-

bium layer is very distinct, three to five cells in width. Within it is the central cylinder, made up of radial rows of parenchyma with some larger, comparatively thick-walled, pitted reticulate, and spirally thickened ducts, single and in groups of two and three. The cells of the parenchyma are filled with a yellow substance soluble in water. Occasionally an oil globule or a sac of calcium oxalate is seen, but neither starch nor tannin is present. In no portion of the root are either bast or wood fibres discernible.

The Powder.—Owing to the absence of particularly characteristic tissue the powder is identified only with difficulty. The collenchymatic tissue lying within the cork is of some value, also the large spiral and reticulate ducts, and the regularity in both size and arrangement of the cells next within the cambium. The absence of bast fibres is of noteworthy importance.

Chemistry.—The bitter principle is gentio-picrin, a glycoside, crystallizable in colorless needles. It is readily soluble in water and alcohol, split up by boiling with weak acids into a fermentable sugar and glutio-genin. The coloring-matter is gentisin (gentianin or gentisic acid) in yellow tasteless crystals of neutral reaction, scarcely soluble in water, more so in alcohol and ether, yielding a brown color with ferric salts. A sugar, gentianose, is found in the fresh root; it is fermentable but does not reduce Fehling's solution. Fat, oil, resin, mucilage, pectin, and 8 to 9 per cent. of ash are also present.

RHIZOMES.

Rhizomes are underground stems and are to be distinguished from roots by the presence of leaves or leaf traces. Rhizomes may be horizontal, oblique, or vertical, and can be distinguished by the situation of the leaf scars or traces of the roots. In horizontal rhizomes the

leaf scars are situated like cups straight upon the upper side of the rhizome while the roots are found beneath. In an oblique rhizome the disposition is the same, save that the leaf scars, instead of being equal, are more or less tilted, one side being deeper than the other. In vertical rhizomes the scars are at the apex and the roots completely encircle the rhizome.

The microscopical structure varies. In pharmacognosy three types of rhizome are met with: the Vascular Cryptogams, the Monocotyledons, and the Dicotyledons.

The rhizomes of the vascular cryptogams are each laws unto themselves, and as the pharmacist need study but one, the description will here be found under *Aspidium*.

The rhizomes of monocotyledons are more uniform in their structure. In general they consist of an external parenchymatous layer, in which a few fibro-vascular bundles may be scattered, and an internal cylinder of parenchymatous tissue in which a number of fibro-vascular bundles are to be found. Separating the two is a layer (or layers) of specially modified cells, the protective sheath or endodermis, the cells of which may be cubical, square, thickened, etc. In general the fibro-vascular bundles are more closely clustered near the endodermis sheath and are built up upon either the concentric or the closed collateral type (no secondary bark as a rule). In general, rhizomes and roots of monocotyledons may show almost the same structure. This is rarely the case in dicotyledons.

The rhizomes of dicotyledons are quite uniform in structure, closely resembling stem structure. In general they consist of a cortical portion in which secondary growth may have taken place to produce cork. The thickness of this cortex varies greatly, and it generally consists of parenchymatic cells; secondary structures may, however, be found therein, sclerotic cells, etc.

From the central woody portion the cortex is divided

not by an endoderm but by the cambium which builds up fibro-vascular bundles of the open collateral type. Phloem is on the outside, xylem on the inside. (Rheum makes a curious exception to this general rule, for in it an anomalous growth is seen, the xylem growing outside the phloem.)

The number of bundles varies considerably and also the elements that go to make up xylem and phloem.

The centre of the stem is occupied by a pith made up in the main of suberized cells.

ASPIDIUM.

Aspidium (Male-fern) is the rhizome of *Dryopteris Filix mas*, Schott, and of *Dryopteris marginalis*, Asa Gray (nat. ord. *Filices*), U. S.

The first-named plant, also known as *Aspidium Filix-mas*, *Polypodium Filix mas*, L., *Polystichum Filix mas*, Roth, *Nephrodium Filix mas*, Mich., *Lastrea Filix mas*, Presl., grows plentifully in both forests and plains throughout the temperate portions of Europe and Asia. In North America it is rarer, growing in the mountains of the western part of the continent.

The less reputed but probably as valuable *Dryopteris marginalis* is found in the eastern portion of the continent.

For a non-tropical fern the plant is fairly large. The rhizome is thick and scaly. From it arise the fronds in a circular tuft; below, it sends down innumerable fibrous roots. It is collected in autumn and should not be used if more than a year old, or when it has lost its internal green color.

The rhizome is collected when the reserve products are in abundance, this being about the latter part of the summer. *D. marginalis* is hardy in New England, remaining green a greater part of the winter; thus it uses up, during the winter, much of the stored food products which are formed in the spring and midsummer. The

dead stalks of former fronds and the chaffy remains of the year's growth should be rejected.

Description.—The slightly oblique rhizome, as it appears

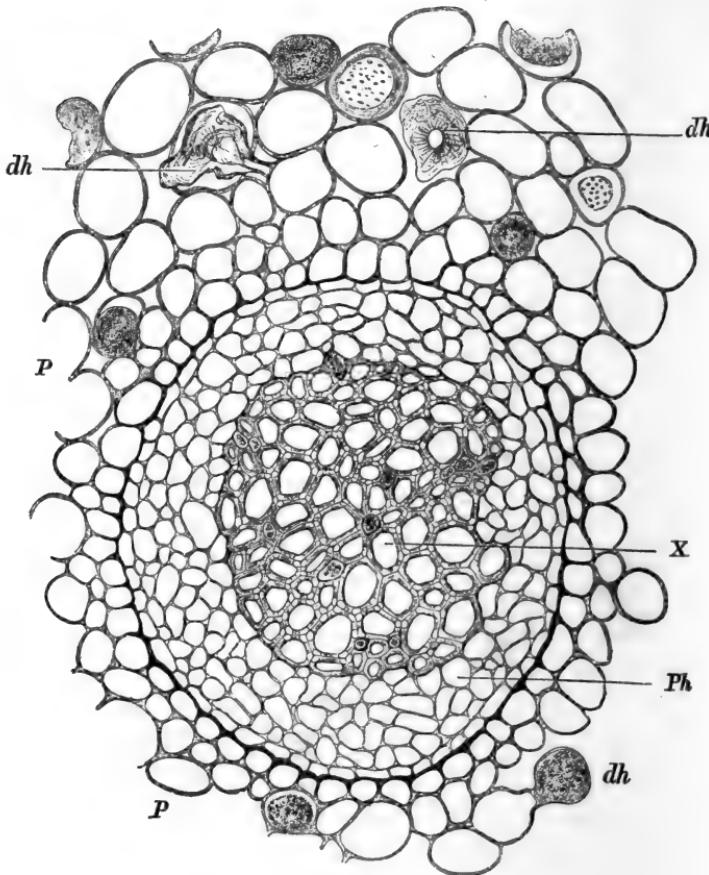


FIG. 25.—ASPIDIUM.

Cross-section of Aspidium: *dh*, Glands, in parenchyma, *P*, which surrounds the concentric fibro-vascular bundle, with *X*, the vessel portion (xylem), made up of tracheids in the centre, surrounded by *Ph*, the sieve portion (phloem), the whole surrounded by the dark lined endodermis (Moeller).

in the market, should be about 1 to 5 cm. in diameter, and from 10 to 25 cm. in length. It is completely covered with the ascending bases of the old stems, which usually

average 5 cm. in length, 0.5-1 cm. in diameter, slightly curved, shining dark-brown. These are closely intermingled with numerous light-brown chaffy scales and numerous delicate branched roots. Internally the rhizome is pale-green when fresh, yellowish and spongy when old. Fragments of the stipes are good when green only. The green character of the internal structure of both rhizome and stipes is essential. This is usually retained for from a half to two years after gathering, at the end of which time the drug is of no value, and, in fact, has suffered a gradual deterioration throughout the whole period.

Histology.—A cross-section of the rhizome shows an angularly irregular outline; without is a layer, six to eight rows deep, of brownish-yellow thick-walled polygonal cells. In the light green thin-walled parenchymatic ground tissue cells are numerous small, round or oval starch grains, single or in groups of two or three. Of frequent occurrence are round intercellular spaces into which project one or more round stalked glands containing the dark green oleoresin. About midway between the centre and periphery of the section is a single circle of six to twelve (*D. marginalis* has five to seven) oval or reniform concentric fibro-vascular bundles arranged with the larger diameters at right angles to the radii. Each of these is surrounded by an endoderm of thickened cells, within which is the phloem tissue of the bundle and the central xylem. The xylem is composed mostly of large, angular, pitted, thick-walled tracheids, with here and there, single or in groups of two, narrow pitted and scalariform ducts, imbedded in starch containing parenchyma. In the outer phloem portion of the bundle three zones of tissue may be distinguished. Within lie one or more rows of parenchyma enmeshing the wide, thin-walled sieve bundles. Surrounding these are several rows of narrow, thick-walled, longitudinally elongated paren-

chyma. The whole is enclosed in the brown, corky, thick-walled endodermis. The sieve tubes are wider than the surrounding cells. Their cross walls are at right angles or only slightly inclined. They and the side walls show many pores closed by the coagulated protoplasmic substance in which are seen glistening spheres. Without this central circle of fibro-vascular bundles are seen irregularly distributed smaller ones. These lead out-

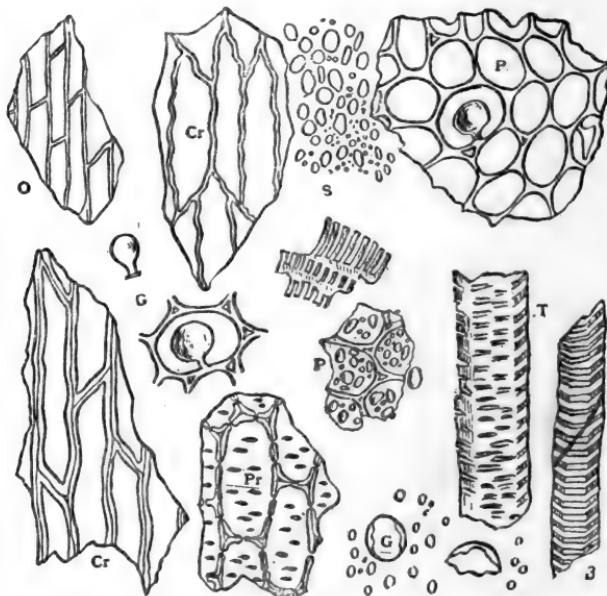


FIG. 26.—POWDERED ASPIDIUM.

S, Starch; G, glands; Pr, pitted parenchyma; P, parenchyma; Cr, thickened cortical tissues; T, tracheids; O, phloem parenchyma.

ward to the fronds and have their origin in the central bundles.

Powder.—This varies greatly in color according to the age of the specimen, from greenish to yellowish, to yellowish-brown. In a powdered condition the color-changes take place more rapidly, even when the powder is kept in a glass-stoppered bottle.

The constituents of the powder, here describing both powders under the same heading, are starch, parenchymatic tissue, thick-walled epidermal structures, vessels, glands, and fragments of roots and chaffy scales. If much stipe tissue is included in the powder, fibres may be found.

The starch grains are suggestive. They are usually simple and exhibit a very great range both in size and shape. In shape they vary from minute spheres to flattened ovoids, and in size from 2 or 3 microns to 4 to 6 or 8 to 12 microns. These larger grains often show small apical irregularities, and are markedly flattened. The hilum is not manifest. With polarized light it is seen to be irregularly situated, sometimes centric, sometimes eccentric; stratification lines are few in the ordinary media used for observation, and with the polarizer, the cross observed in so many of the starch grains is only infrequently seen. The parenchymatic cells are commonly packed with starch grains. They vary in the character of the cell wall, some thin, others thicker and pitted, with irregular outlines, somewhat cuboidal in shape, and they vary in diameter in the different parts of the same rhizome; measurements gave the range from 50 to 80 microns.

Thick-walled epidermal structures are appreciable in those powders which have been made from the rhizome and stipes, in their natural condition; powders made from peeled or prepared specimens lack this thick-walled tissue. These cells are somewhat elongated and flattened, with slightly wavy and thickened cell walls, not infrequently sharp-pointed. Their color is dark-brown to yellow, and when found they form a striking feature of the powder. Cells from the outermost layers of this cortical tissue have cell walls which are much thicker than those further in.

The vessels of aspidium are extremely large, and as a rule, fragments only are found. These show the typical

reticulated tracheid-like construction characteristic of many of the ferns. The tracheids are much of the same character, varying only in the complexity of their markings and in their diameters. Some of the tissue of the phloem may be seen. This consists of elongated and very delicate thin-walled cells, which are much crushed and contorted in the powdering. Characteristic features of this rhizome are the glandular structures. These are found in the parenchymatic tissues, or, more frequently, broken into small fragments and free; when perfect they consist of small dark-brown sacs, filled with resin, and averaging 25 to 40 microns in diameter; a minute stalk may sometimes be noted. If the rhizome is particularly old and much stipe tissue included in the powder, typical bast fibres may be found.

Chemistry.—Male-fern contains the crystallizable or amorphous filicic acid whose reputation as the sole active constituent is disputed. It is, at least in the crystalline state, odorless, tasteless, insoluble in water except with an alkali, but quite soluble in absolute alcohol and ether. Other constituents are filicic tannic acid (10 per cent.), fixed and volatile oil, resin, sugar, and starch.

CALAMUS.

The rhizome of *Acorus Calamus*, Linné (nat. ord. *Aroideæ*).

Habitat.—Europe and North America, in wet meadows and on the banks of streams and ponds.

Description.—In sections of various lengths, unpeeled, about 2 cm. broad, subcylindrical, longitudinally wrinkled; on the upper surface marked with leaf-scars forming triangles, but on the lower surface with the circular scars of the rootlets in wavy lines; externally reddish-brown, somewhat annulate from remnants of leaf-sheaths; internally whitish, of a spongy texture, breaking with a short, coky fracture, showing numerous oil-cells and

scattered wood-bundles, the latter crowded within the subcircular endoderm. It has an aromatic odor, and a strongly bitter taste.

Histology.—The cross-section reveals an outer zone, about 1 to 3 mm., covered on the outside with a thin epidermis, and enclosing an inner cylinder containing numerous vascular bundles. The underlying tissue resembles collenchyma, which on the inner part

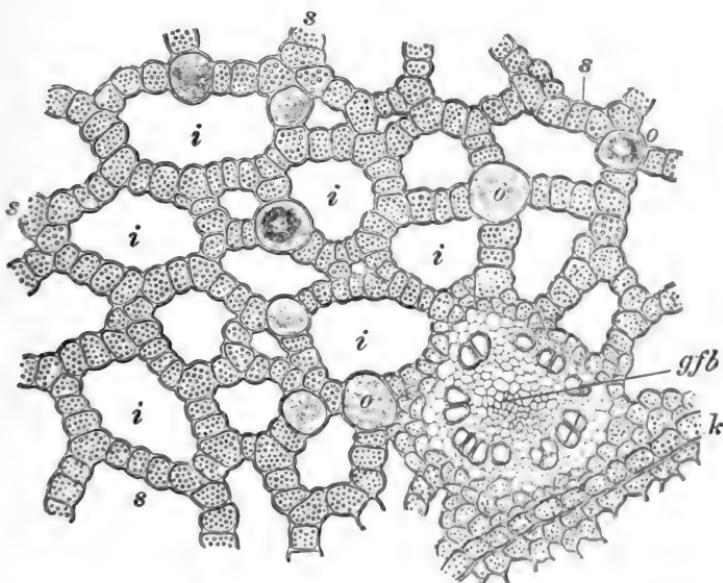


FIG. 27.—CALAMUS RHIZOME.

Cross-section: *s*, Starch-filled parenchymatic cells; *i*, intercellular spaces; *o*, oil cells; *gfb*, fibro-vascular bundle; *k*, cambium.

gives way entirely to loose-meshed parenchyma, which encloses large cellular spaces. The inner parts of the exoderm, and of the central tissue, consist simply of one-layered cell sheets which separate the long cell spaces which extend in the direction of the axis. Together with each string or sheet of cells, there is a nearly spherical oil cell. The adjoining parenchyma is filled with granules of starch, which is mixed with, or accompanied by tannic

acid. There are also cells filled with ethereal oil in the exoderm. The endoderm is composed of cells which are not very prominent, and extend only a short distance longitudinally. Deep within the endoderm the vascular bundles are more numerous; they resemble in their course the palm-type of cells, since they penetrate the tissue like leaf-vessel bundles and join with the central bundle. The bundles are concentric and carry the sieve tubes in the inside. In the outermost zone, the collenchymatic zone, there are single short sclerenchymatic fibre bundles.

Chemistry.—Kurbatow has isolated a sesquiterpene ($C_{15}H_{24}$) which boiled at 255° . Flückiger, on the contrary, isolated an oil of the apparent formula $C_{10}H_{16}O$, which boiled at 255° . The crude calamus oil has a somewhat dark-brown color. Such a discoloration may be due to the mixture of a blue oil. Calamus oil furnishes a small amount of such a blue constituent, after the distillation of the principal part of the mixture at 270° to 290° . In addition, it appears to contain a phenol, since the portion which has the highest boiling-point is colored greenish-brown by alcoholic ferric chloride.

Acornin, $C_{39}H_{60}O_6$, is a very bitter, soft glycoside. It was prepared by Thoms by heating the calamus root with water, evaporating the solution after the addition of animal charcoal, and exhausting the residue with boiling alcohol. The product was less than 2 per mille. It is neutral, insoluble in water, soluble in alcohol, chloroform, and ether. Other constituents of calamus are resin, starch, mucilage, calamine, and choline; the latter forms in decomposition, trimethylamin and methyl-alcohol.

PODOPHYLLUM.

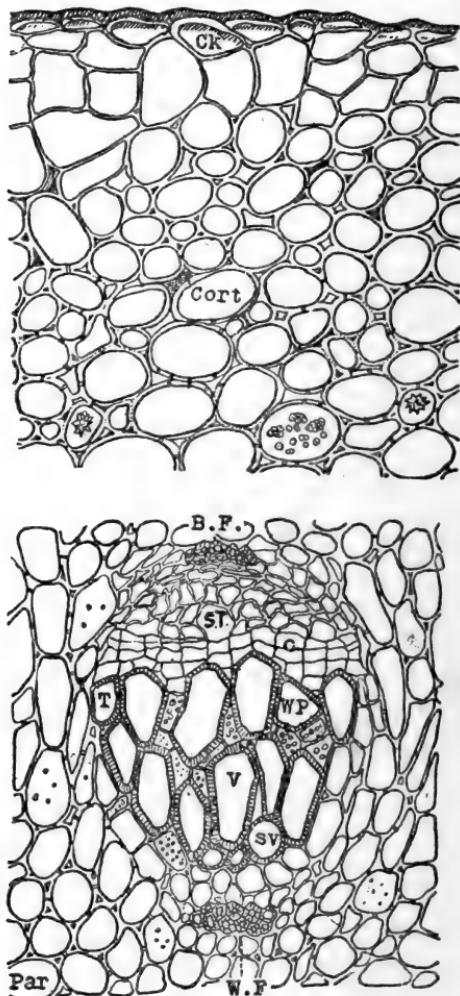
Podophyllum is the rhizome and roots of *Podophyllum peltatum*, L., a plant found abundantly in certain localities of the United States. It is very common in north-

western New York and its cultivation could be developed to an industry. The plant is well known and is characteristic by reason of its leaves and striking white blossom in spring, and later in the year by its fruit. This, when ripe, is pleasantly acid and is devoid of purgative properties.

Description.—The rhizome of the market is composed of pieces from 4 to 12 cm. in length and about 0.5 to 1 cm. in width. It has flattened joints at intervals of from 4 to 6 cm. which bear on their upper surfaces the cup-like scars of the single stems, and from their lower surfaces a number of delicate roots. Between the scars the rhizome is cylindrical and smooth, sometimes slightly wrinkled in drying, and light brown in color. It has a sharp fracture, is hard and short, to waxy. The odor is very slight; sweetish taste, later mucilaginous and acrid. In drying, the root contracts but little, and the fresh specimens closely resemble the market varieties, varying only in the lighter color and the fuller firm character. Stems rarely enter into commerce, though stem elements have been detected by the writer in some powders. This should be considered as a very rare adulteration.

Histology.—Under a low power, a cross-section of the fresh root, between the nodes, shows on the outside a brown epidermis encircling a whitish to grayish-white cortical layer; within this there is an irregular circle of separated oval fibro-vascular bundles, varying in number from eighteen to thirty. Within them there is the central cylinder of parenchymatic tissue, the pith, connected with the parenchyma of the cortical cylinder, between the bundles by parenchymatic strings.

With a high power the epidermis is seen to consist of one or two layers of cutinized cells. In old specimens and in the region of the nodes this layer is more distinctly corky and is frequently four or five layers thick. The average size of these cork cells is 0.022×0.045 microns. The cortical layer averages about twenty layers of

FIG. 28.—*PODOPHYLLUM RHIZOME.*

Upper figure, section of cortex; lower, of fibro-vascular bundle: Ck, Corky layer; Cort, cortical parenchyma, with starch grains and crystals, represented in single instances only; BF, bast fibres; ST, sieve tubes; C, cambium; T, tracheid; WP, woody parenchyma cells; V, vessels; SV, spiral vessel; WF, wood fibres; Par, parenchyma of center (pith).

parenchymatic cells down to the circle of fibro-vascular bundles. The cells bordering on the epidermis are slightly collenchymatic and average about 45 microns in diameter. A great degree of polymorphism exists in these parenchymatic cells of the cortex. They vary greatly in size and shape, yet in general conform to the oblong cylindrical type. The cells of the middle of this layer are on the average larger than those on either side, measuring about 100 microns on cross-section and 140 microns in length. Most of them are filled with starch grains, and in the regions of the nodes large rosette-shaped crystals are frequent. The regions between the nodes are poorer in such crystals in the fresh specimens. The circle of fibro-vascular elements is quite irregular. The bundles vary in completeness in a given cross-section, and also in different parts of the rhizome. As a rule, they become larger and more fully developed as the nodes are reached. The bundles are distinctly separated and are typical. The xylem consists of ducts, tracheids, woody parenchyma, and a few wood fibres. The ducts vary from five to ten in number, and are of the reticulated and pitted varieties. A few spiral vessels are to be found in the inner angle of the bundle. Tracheids are few and present no noteworthy features. Woody parenchyma is not abundant, and many of the bundles have no wood fibres, save in the region of the nodes, where they become very marked and characteristic. The cambium is irregular and delicate, and is rarely found reaching across the interfascicular space to join the cambium of the adjoining bundle; thus there is no well-marked cambium ring either in the root or in the stem. The phloem contains sieve tubes, accompanying cells, a few cambiform cells, and a few bast-fibres. There is nothing peculiar in any of the phloem elements, though many of the sieve tubes become occluded to form keratenchyma. The sieve plates are in many cases horizontal. The parenchyma of the

centre resembles that of the outside. The cells are filled with starch and are pitted, and contain few crystals.

The structure of the stem, or practically the leaf stem, is interesting in that the arrangement of the bundles is very irregular and the bundle is of the closed collateral

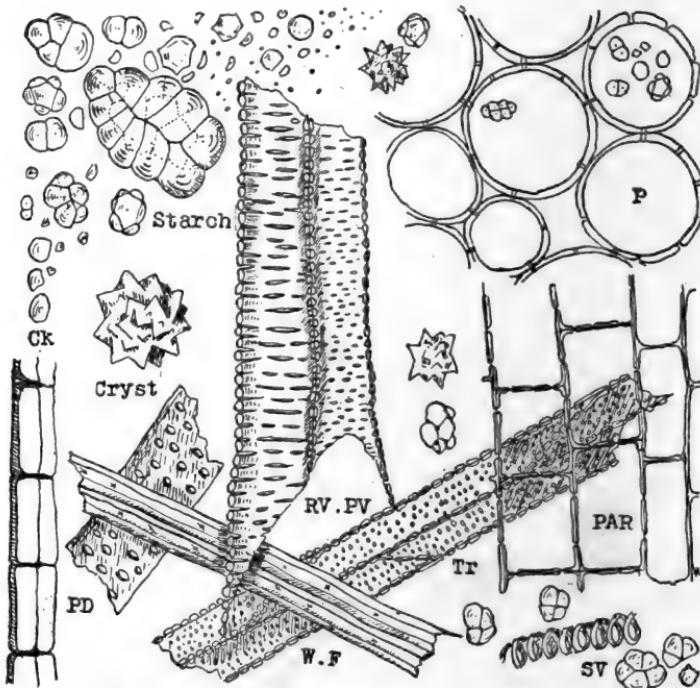


FIG. 29.—PODOPHYLLUM IN POWDER.

Starch; Cryst, crystals of calcium oxalate; Ck, corky tissue, side view; PD, duct with bordered pores; RV, PV, reticulated and pitted ducts; Tr, tracheids; SV, spiral vessel; WF, wood fibres or bast fibres; PAR, parenchyma, in longitudinal view; P, parenchyma in cross-section.

type, so characteristic of the monocotyledons, though not unknown for dicotyledons, as, for instance, in the stems of *Ranunculus*.

Powder.—The most characteristic and conspicuous features of the powder are starch grains, crystals, vessels, parenchyma, and fibres. Less conspicuous tissues found

are sieve tubes, cork cells, tracheids, and wood parenchyma.

The starch is fairly typical. In the fresh condition it is seen to consist of compound grains made up of from five to twenty granules. In dry specimens of the market, the grain is found to be broken up, and is apparently much simpler in structure. The average diameter of the grains is from .8 to 14 microns. The larger granules measure from 4 to 6 microns. The hilum is inconspicuous and concentric markings are few.

The crystals are not very numerous, yet are large, well-marked rosettes. They average from 40 to 80 microns, in several specimens examined.

Reticulated and pitted vessels are the most characteristic in the powder. Fragments measure about 40 to 100 microns. The parenchyma, starch-filled, is thick-walled and pitted, and the cells average from 40 to 100 microns. The fibres in old dried specimens colored yellow are not as frequent and typical; tracheids average about 25 microns across. Here and there in a field in the powder of the dry drug, masses of resin-like material may be encountered.

Chemistry.—Water will precipitate a resinous body called podophyllin from the alcoholic extract. This podophyllin contains fatty oil, extractives, a yellow pigment called podophylloquercetin, an acid, podophyllinic acid, and picro-podophyllin and podophyllotoxin, which latter can be split up into the former and picro-podophyllinic acid.

ZINGIBER. GINGER.

The rhizome of *Zingiber officinale*, Resave. The year-old roots are those in commercial use. Ginger is cultivated in the West Indies and in the tropics generally.

Description.—Practically the cultivated rhizome alone comes into the market at present. It is a large flattish-branched rhizome, about 7 cm. long and 2 cm. thick.

The branches are more or less finger-shaped, flattened, and generally collected along one side.

The odor is pungent, the fracture short, sharp, and uneven, showing yellowish to grayish-yellow interior (yellowish fibro-vascular bundles on fracture). There is considerable variation in the external appearance, different packers in different countries shipping it in their own peculiar fashion.

The main types that come into our markets are: Jamaican, coated and uncoated, only the latter recognized by Pharmacopoeia; African; East Indian; Chinese.

The Jamaica ginger is usually selected more carefully than the other types. It is first peeled and scraped and then dried rapidly in the sun. This gives it a whitish appearance which is a mark of good quality. The rhizome is generally more slender than in other types of ginger and rounder; the lobes are more pointed.

East India ginger is generally peeled on the broad face only. Sometimes it is peeled, and then as it dries, if of a darker color than the Jamaica, it is dipped so as to simulate it, or is bleached with chlorinated lime, calcium sulphate, sulphur, or chloroform.

African and Chinese ginger are both generally coated. Sometimes they are half peeled. The Chinese ginger has short and stumpy stems.

Histology.—Examined under the low power a cross-section shows, if unpeeled, an external layer of brown, corky epidermal cells, within which is found a small grayish parenchymatic cortex, separated by means of an endodermis from a central cylinder of parenchymatic tissue more or less filled with fibro-vascular bundles and secretory organs. The cortex also contains a number of fibro-vascular bundles. The parenchymatic tissues are filled with starch. A yellowish color of the parenchyma is considered a sign of good quality. The fibro-vascular bundles appear as dark brown points in the field. Under

the high power the epidermis shows several layers of corky tissue. Just beneath the cork layer the paren-

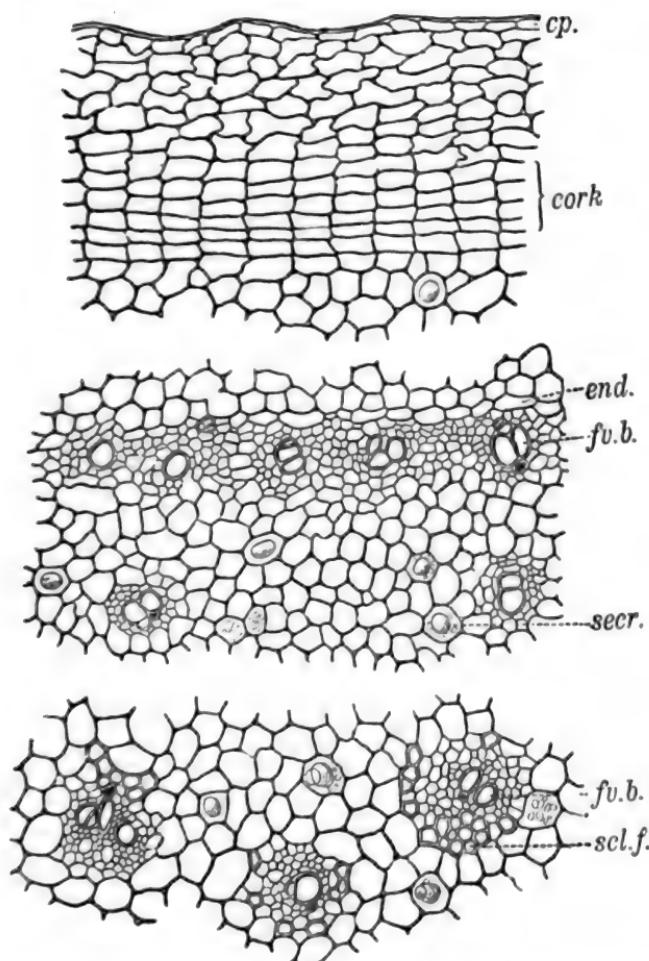


FIG. 30.—GINGER.

Cross-section ginger rhizome: *cp.*, Epidermis; *end.*, endodermis; *fv.b.*, fibro-vascular bundles; *secr.*, oleoresin cells; *scl.f.*, wood fibres (Greenish).

chyma is free from starch and rich in secretory reservoirs. The parenchymatic cells of the cortex are polyhedral, isodiametric, and thin-walled, and are separated by

small intercellular spaces and numerous clearly marked starch grains with eccentric hilums. The cortex contains a number of secretory reservoirs which are about the shape and size of the parenchyma cells, or slightly larger; the cell walls of these are suberized and they contain yellowish ethereal oil, which at times becomes resinous. Numerous small calcium oxalate crystals are present.

The fibro-vascular bundles of the cortex are rudimentary or built on the same plan as those inside the endodermis. The endodermis is composed of one to three layers of much contorted, slightly elongated cells whose walls are comparatively thick, compressed, and somewhat suberized. Some annular reticulated vessels are often found close to the endodermal sheath.

The central portion consists mainly of parenchymatic tissue similar to that in the cortex. The fibro-vascular bundles are of the closed collateral type. The xylem consists of from three to eight tracheids and a few spiral vessels or spiral-like tracheids.* These are surrounded in part by a varying number of sclerenchymatic elements with pores with cross partitions which are slightly lignified. These elements are more numerous on the tracheal side of the bundle. At times they surround the bundle completely. Secretory cells are sometimes found in this portion of the rhizome. The phloem is made up of parenchyma and a few sieve tubes with oblique walls, surrounded by parenchyma cells.

The starch of ginger is of diagnostic importance. In the powder the presence of much corky tissue is indicative of the fact that the outer rind has not been removed.

Adulterations of powder are not rare.

Chemistry.—Two to six per cent. ethereal oil, Terpene, Acid, three to five per cent. ash.

* A. Mayer: Arch. d. Ph., 1881, S. 422.

CURCUMA. TURMERIC.

The rhizome of *Curcuma longa*, L. (*Curcuma rotunda*, L., *Amomum*, Jacq.). Nat. Ord. *Scitamineæ*.

This is a perennial plant with long sheathing radical leaves. A native of India, it is cultivated throughout that country, southern and eastern China, and the islands of the East Indies. It grows also in Africa and Brazil. The main portion of the rhizome from which the leaves emanate constitutes round turmeric; its cylindrical or fusiform rhizome branches form the long turmeric of commerce.

The rhizome sends out long, tough, very fine root fibres, which sometimes develop at some distance from their source into oval tubers, which consist, when young, almost entirely of pure white starch, but when older develop the yellow coloring-matter characterizing the rhizome.

Description.—The rhizome appears in the market in the two forms characterized. The round turmeric comes in round or pear-shaped masses, hard and dense, exteriorly gray to light yellow, internally reddish-yellow. The diameter is from 1 to as much as 30 cm. (Flückiger). The large rhizomes are cut transversely and all are scalded to facilitate drying. The upper portion shows numerous stem scars arranged in concentric circles; below are the large irregular scars of the rhizome branches, and here and there a fine tough root fibre. The surface between the markings is nearly smooth above, irregularly wrinkled below. Long turmeric comes in tapering cylindrical pieces, sometimes branched like ginger, but usually simple, with large orange-colored scars. It is indistinctly ringed, rough with deep irregular wrinkles. The fracture is sharp, shining, and resinous, the odor slightly aromatic, the taste pleasantly aromatic and somewhat pungent. The varieties are: the Chinese,

which is not common; Madras, which comes in rather large central rhizomes with golden yellow branches; Bengal, which in spite of its dull gray surfaces contains the most color; Cochin, which comes in sections or slices of a rather large rhizome; and Java, in small pieces of little esteem.

Histology.—The bark, about one-sixth the thickness of

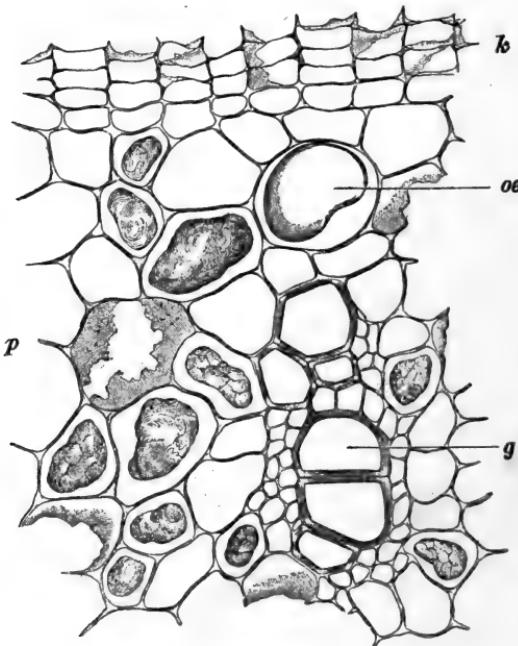


FIG. 31.—CURCUMA.

Cross-section cortical portion of turmeric rhizome: *k*, Cork; *p*, parenchyma with swollen starch masses; *oe*, oil cells; *g*, portion of vessel bundle (Moeller).

the wood, bounded by an epidermis of thin-walled polygonal or round corky cells, consists of two layers, the outer of irregular pitted parenchyma with somewhat thickened corners without definite arrangement, the inner of regular rectangular cells in radiating rows developed from phellogen. On the surface are numerous

thick-walled, mostly single-celled, blunt-pointed trichomes, and here and there stomata. Oil cells are of occasional occurrence. More numerous are the elongated resin cells. The larger portion of the parenchyma is well filled with starch, which by the scalding swells up to form pasty masses which retain the form of the enclosing cell even in the powder. The grains in their natural form are small, 15 to 30 microns long, oval, triangular, or three-sided, sometimes long and thin or disc-shaped. The concentric rings are visible but indistinct. The hilum is at the smaller end. Here and there throughout the bark are isolated irregular fibro-vascular bundles, the numerous small angular sieve tubes surrounding the rather large-celled vessel portion. Occasionally in the parenchyma are found very small angular crystals of calcium oxalate.

A distinct endoderm of tangentially elongated cells separates the cortical from the inner portion of the rhizome. The structure within is in general similar to that of the outer portion. The fibro-vascular bundles, however, are much more numerous, especially near the endoderm, where they merge into one another. They are usually concentric, as in the cortical tissue, but here and there an isolated bundle shows a rudimentary bicollateral structure. The vessels show markings between spiral and net-formed. The sieve tubes are weak with distinct sieve plates. The parenchyma is filled with starch. Resin cells are frequent, oil cells less so.

Powder.—The curcuma in powder is easily recognized by its characteristic color, odor, and taste. It tinges the saliva yellow. The united masses of starch grains retaining the shape of their enclosing cells make up the greater portion. Isolated grains, uninjured by heat, are also met with. The tissue elements, cork, parenchyma, and ducts, are of no diagnostic value. The absence of bast fibres is noteworthy.

Chemistry.—A yellow volatile oil 1 per cent., a thick oil, turmerol, boiling-point 285° to 290° C., of an aromatic odor, and another less viscid body, the yellow coloring-matter curcumin, crystallizing in shining blue crystals, yellow by transmitted light, form the principal constituents. Fat and starch in some quantity, gum and resin are also present.

TUBERS—BULBS.

SQUILL.

The bulb of *Urginea maritima* deprived of its dry membranaceous outer portion and cut into thin slices, the central portions being rejected, of the natural order *Liliaceæ*, a native of the Mediterranean basin, growing in the neighborhood of the sea-coast. Two varieties are known, the white and the red, the former of which is preferred. The bulbs should be collected in summer or autumn, after blossoming but before the leaves have commenced to develop.

The chief microscopical elements of the powder are crystals, parenchymatic tissue, epidermal cells with few stomata, and spiral vessels. Starch is absent, though at certain times the vessels contain a few small starch grains.

The crystals of calcium oxalate are very prominent; they are of the acicular type, and vary greatly in size; some are extremely fine, others large or coarse, at least one millimetre in length. They appear round but are somewhat quadrate, belonging to the quadratic octahedral system. These crystals are usually found in all sorts of fragments; they are rarely found in the sac-like parenchymatic cells in which they are formed. They constitute from 3 to 4 per cent. of the drug.

The parenchyma is elongated polyhedral and thin-walled, and much contorted, many of the cells containing, in the powder, irregular clumps of mucilaginous

material. A few elongated stomata are sometimes seen in the outer thicker-walled fragments of epidermis.

The vessels are usually lax, and of the spiral type; fragments of broken spirals are common in the powder.

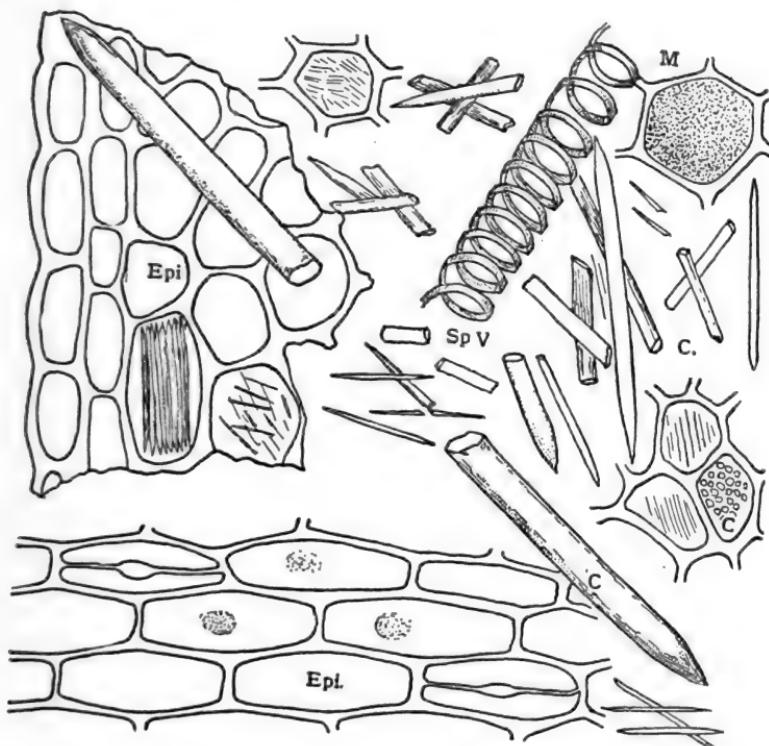


FIG. 32.—SQUILL IN POWDER.

Epi, Epidermal cells with stomata, below; above, cross-view showing crystal sac; C, crystals in various stages; Sp V, spiral vessels; M, mucilage cell.

COLCHICUM.

Colchicum is the corm and seed of *Colchicum autumnale*, L., natural order *Liliaceæ*, a native of central and southern Europe, England, and North Africa. The corm is most active after one year and should be gathered from June to August of the second year, after the seeds are ripe.

The color of the powder is whitish; with age it becomes grayish to brownish white. The taste is acrid. The powder, under the microscope, shows the following general elements: Starch, ducts, and parenchyma; the starch predominating.

The starch is abundant; the grains are large and characteristic. They are mainly compound, in groups of

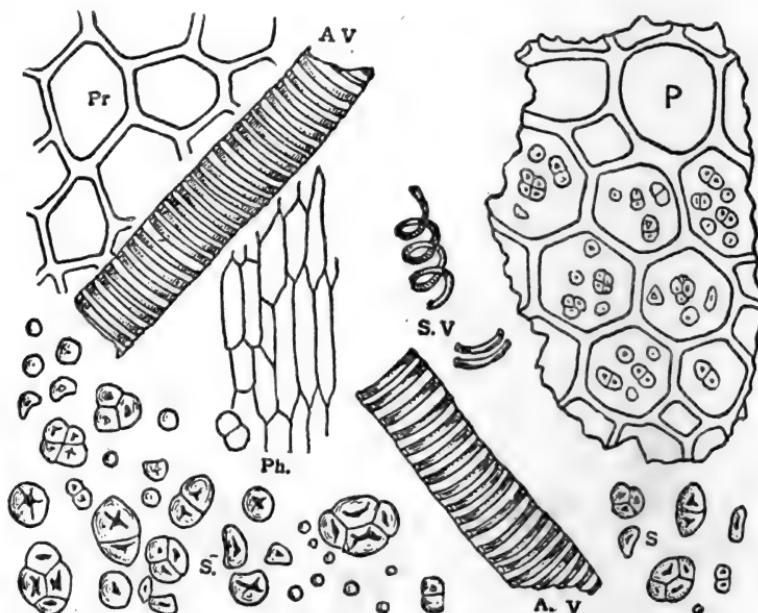


FIG. 33.—POWDERED COLCHICUM.

S, Starch grains, simple and compound; P, Pr, parenchyma; AV, SV, annular and spiral vessels; Ph, tissues from the phloem.

two, three, or four, with central hilums, which are triangularly or quadrangularly lacerate, or sometimes distinctly many-rayed. The concentric markings are not prominent. The polariscope cross is usually rectangular, swollen in the middle, and attenuate at the periphery. The grains range from 5 to 22 microns in diameter.

The ducts are not numerous; they are usually spiral or annular, sometimes pitted.

The parenchyma is usually thin-walled, inclined to be regular, and filled with starch grains; the parenchymatic meshes range from 60 to 100 microns.

ACONITE.

Aconite is the tuber of *Aconitum napellus*, L., natural order *Ranunculaceæ*, and grows pretty widely over the northern hemisphere. It is extensively cultivated in Germany, France, England, Switzerland, and India. The tuber should be gathered in winter or early spring—in some climates October seems the best month for collection—from plants over one year of age.

Powder.—The powder in bulk is brownish-gray and has the peculiar taste, followed by tingling, characteristic of the drug. Microscopically the following constituents are recognizable in powder No. 60: Starch, parenchymatic tissue, cork cells, stone cells, endoderm cells, ducts, tracheids—sometimes a few wood fibres and also a few epidermal hairs.

The starch is made up of grains which are mainly compound, growing in twos or threes, though often in groups of four, occasionally in groups of eight. The hilum is usually centric, mostly simple, sometimes fissured; concentric markings may be made out in some of the numerous single grains. By polarized light the cross is broad and distinct, its arms at right angles. The average diameter of the single grains varies from 5 to 15, the compound grains from 10 to 20 microns. The starches of the other species of aconite are in the main similar; that of *A. ferox* examined showed fewer compound clusters, and the polarization cross was less distinct. *A. Japonicum* had uniformly larger grains, the single grains being often twice the size of *A. napellus*, and the concentric markings much more distinct. The polarization cross was indistinct in specimens examined.

Stone cells are among the most characteristic features

of the powder of aconite. They are elongated, varying from two to four times as long as broad; the walls are markedly thickened and the pores are simple and deep;

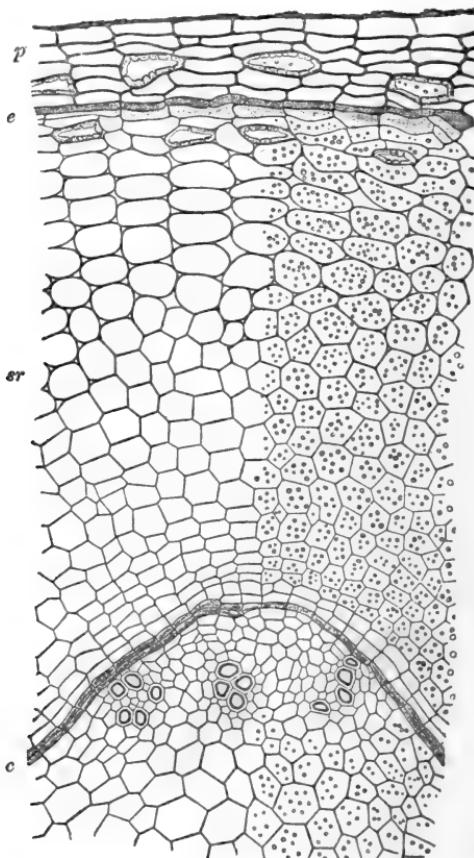


FIG. 34.—ACONITE.

Cross-section of tuber of *Aconitum napellus*: *p*, Parenchyma; *e*, endodermis; *sr*, cortex; *c*, cambium, stone cells at periphery, vessels within the cambium (Tschirch).

they are usually colored brownish. The general size is from 20 to 60 microns.

There is little characteristic of the parenchyma; it varies greatly in size in the different parts of the tuber,

hence a uniform size in the powder is not to be expected. The cells are mainly rounded, and the walls are somewhat thickened and collenchymatic, especially near the epidermis; the parenchyma inside of the endoderm is

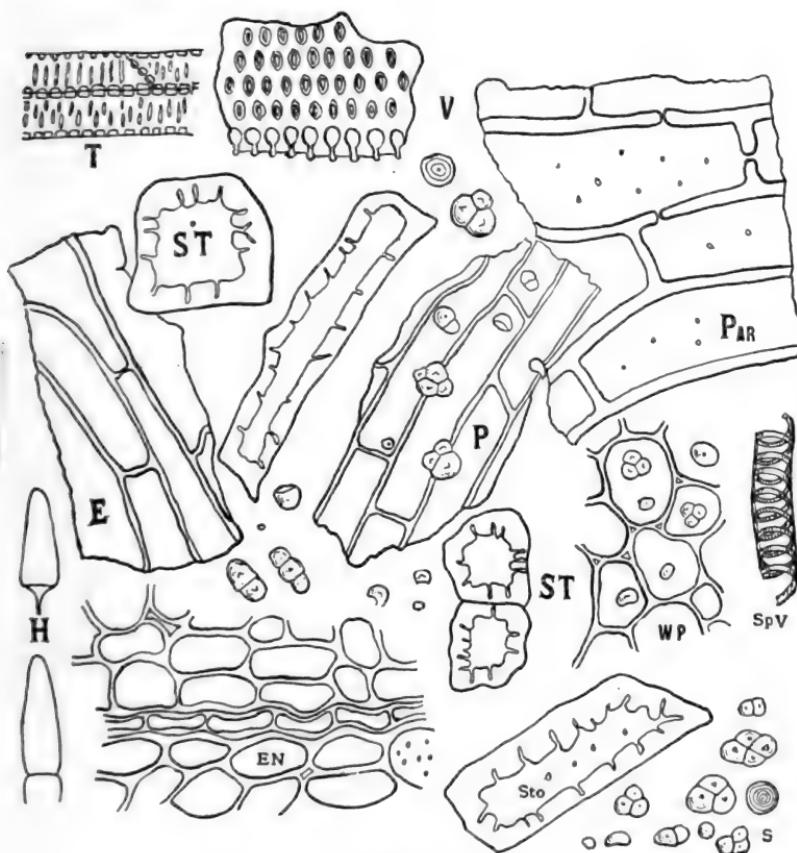


FIG. 35.—POWDERED ACONITE.

T, Tracheid; V, pitted vessel; S, starch; ST, Sto, stone cells; H, hairs; P, PAR, parenchyma; EN, endodermis; WP, wood parenchyma; Sp V, spiral vessel; E, epidermis.

richly pored. The cells of the epidermis are usually light-brown in color, thin-walled, and are not characteristic. Occasionally a few epidermal hairs are seen. These come from the lower part of the tuber or from the

minute side rootlets. The vessels vary widely, may be thick-walled, and the fragments usually show traces of the pores, which are slightly bordered. Sometimes spiral vessels are found. Small fragments of woody parenchyma containing starch grains are also met with.

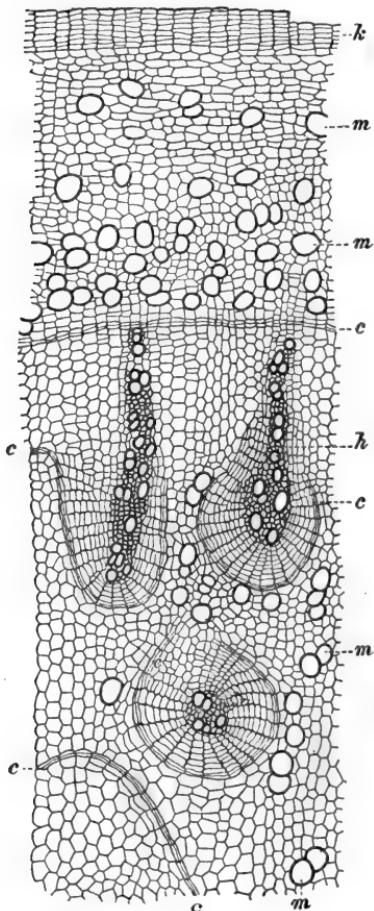


FIG. 36.—JALAP.

Cross-section through the outer portion of jalap tuber: *k*, Cork; *m*, milk tubes; *c*, cambium; *h*, vessel portion (Tschirch).

ferred. The powder is dark-brown.

The more prominent microscopical constituents are

JALAP.

Jalap is the tuberous root of *Ipomoea Jalapa*, a native of damp shady woods of eastern Mexico and the surrounding provinces. It is now also in cultivation in Jamaica and in the Nilgherry mountains of India. Jalap is gathered at all times of the year, hence there is a great variation in its constituents, especially the starch, some specimens being very rich in this ingredient and on account of this generally less valuable. These specimens break with a mealy fracture. Others contain very little starch, have a tough fracture, and are dark-brown and shiny on the broken surface. As a rule, such are to be pre-

starch, ducts, crystals, tracheids, resin masses, and parenchyma.

The starch grains of jalap are large; simple and compound forms abound. The larger simple grains are gen-

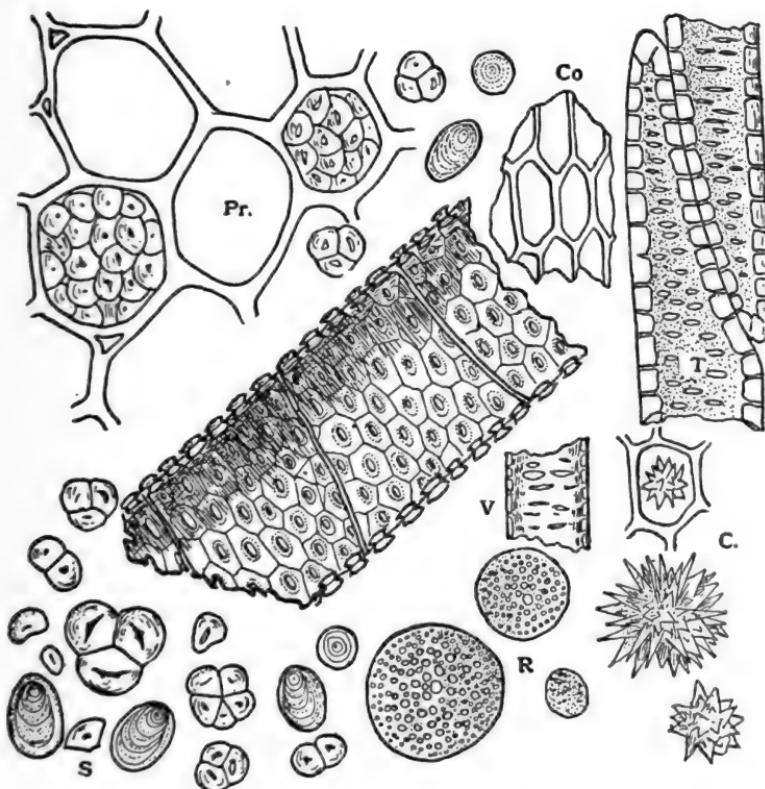


FIG. 37.—JALAP IN POWDER.

S, Starch; C, crystals; R, resin globules; Co, corky tissue; Pr, parenchyma; T, tracheid; V, vessels with slit-shaped and border pores.

erally dense, rounded or broadly oval, sometimes ovate, with an eccentric, generally simple, hilum and pronounced concentric markings. Their polarization cross is irregular. The smaller simple grains and the compound grains, which latter are in twos or threes, rarely more, have

central and usually lacerate hilums. The grains range from 10 to 35 microns in size. In the artificial heat of drying many of the starch grains are apt to be altered, especially those near the epidermis of the tuber. The resin masses are prominent, they are usually spherical, light to dark-brown, and minutely irregular or with larger drops of oil. The crystals vary; they are of the spheroidal, spiny type and average from 20 to 40 microns.

The parenchyma is very abundant; it is lax, thin-walled, and usually non-pored. The tracheids are few, and have simple slit-like markings. The vessels are few but large, the fragments sometimes showing the markedly regular border pores. The cells of the epidermis are generally elongated, hexagonal in shape, and are dark-brown to black.

WOODS.

The woody tissues form, as a rule, the greater part of the mechanical tissues of the plant, and in some plants by far the greatest amount of material in the stem is made up of woody fibres.

There are but few official woods, as we know from the physiology of the plant that the woody fibres serve mainly to support and conduct air and water only; in the bark the more active life processes of the plant are constantly taking place, and hence more active chemical compounds are found in the bark. This lack of active chemical compounds accounts for the few official woods.

Starch and sugar are sometimes found lying free in the woods, but rarely nitrogenous substances nor alkaloids. Heart woods frequently contain tannin and resin, coloring-matter forming part of cells or the cell walls.

The proper contents of the woods are reserve-stuff materials, aromatic bodies, ethereal oils (Juniper, Sassafras), resin (Guaiac), tannin and coloring-matters (Hæma-

toxylon and Santalum), bitter products (Quassia)—in general, products of destructive metabolism.

Although from the medical standpoint the woods are of small interest, they are of more importance to the pharmacognocist, for they are frequently used to adulterate ground drugs, and they form, though in small quantities, an important part of the stems and roots of official drugs.

In the narrow sense of the word the "woods" include the xylem elements of the dicotyledonous stem; the phloem elements of the bundle generally adhere to the bark.

These elements, it may be recalled, are:

- (1) Ducts or vessels.
- (2) Tracheids.
- (3) Woody fibres (libriform).
- (4) Parenchyma.
 - (a) Wood parenchyma.
 - (b) Simple parenchyma.

(1) The *ducts* or *vessels* are characteristic of woody tissues. They are usually lignified, have thick walls, and the end cell membranes have become absorbed. The walls are provided with variously shaped and sized pores and may be sculptured in a variety of ways, giving rise to the various types of vessels.

(a) *Spiral*.—Cell wall thickening spiral.
(b) *Annular*.—Cell wall thickening annular or ring-like.
(c) *Reticulated*.—Cell wall thickening net-form.
(d) *Pitted*.—Pits or pores which may be *simple* or *bordered*. Various transitional forms are to be encountered and they all spring from the cambium.

(2) The *tracheids* are to be distinguished from the ducts by the presence of cross walls that have not been absorbed. In other respects they resemble the ducts quite closely.

The wood of the Conifers is distinguished by having

nothing but tracheids. The woody cylinder in the root of Ipecac consists entirely of tracheids.

(3) The *libriform* or *wood fibres* make the largest mass of the wood. They are generally packed about the vessels, supporting them. They are elongated elements with rounded or sharpened ends, thickened lignified walls, and provided with left oblique, slit pores, in all respects similar to the bast fibres, from which they can be distinguished with difficulty.

(4) The *parenchyma* may be of two kinds: (a) Woody; (b) simple.

(a) Woody parenchyma is, as a rule, found in small quantities in the wood, immediately surrounding the vessels or arranged in radial rows between the vessels.

Parenchyma may be difficult to distinguish from libriform in long section. Shortness is diagnostic. The simple pores are also diagnostic. Medullary ray cells closely resemble woody parenchyma in cross-section in many woods.

(b) Simple parenchyma may be irregularly scattered in small amounts among the various elements of the wood. Its thin-walled isodiametric cells with simple pores are sufficiently distinctive. Rarely does the simple parenchyma become sclerotic.

Transition forms among the elements are to be expected, and to these much of the difficulty in determination of powders is due.

Excretory reservoirs (oils, mucilage, tannin) are rare in the official woods (Sassafras).

Crystals are sometimes found in the woody parenchyma of the medullary rays and sometimes in the simple parenchyma.

Secretory reservoirs, both schizogenous and lysigenous, are met with. In *Pinus*, *Eucalyptus*, etc., the oil, resins, and balsams are contained in schizogenous reservoirs, as also in the root of *Arnica*, *Angelica*, etc.

Schultze's maceration fluid is an invaluable help in the study of the isolated parts of the wood and should be constantly employed.

QUASSIA.

The wood of *Picræna excelsa* (Swartz), Lindley. Jamaica.

In the German Pharmacopœia both Jamaica (*P. excelsa*) and Surinam (*Quassia amara*) Quassia are mentioned. In billets of various sizes, dense, tough, of medium hardness, porous, with a minute pith and narrow medullary rays, inodorous and intensely bitter. In the shop it is met with in the form of chips or raspings of a yellowish-white color.

Description.—The bark is 0.5 to 1.0 cm. wide, and breaks off quite readily. It is of a dark color and shows on cross-section a radial irregular structure. Beneath the end is a narrow, grayish layer, beneath which is the main body of the wood, showing a number of ducts and medullary rays. Central pith in the interior. The cells of the periderm are oblong, the outer ones being stained dark-brown. The parenchyma of the outer layer is rich in calcium oxalate crystals.

Jamaica.—Elements large; medullary rays two to five, lying close to vessels. Single calcium oxalate crystals in woody parenchyma. Pores elongated radially (crystal cells); more bordered pores.

The phloem contains bast fibres which are well marked, cambiform cells, and sieve tubes which are somewhat contorted and irregular.

The medullary rays are some two or three cells in width, contain starch, and widen out very markedly in the phloem portion of the bundle.

The xylem contains: Vessels, tracheids, woody fibres; woody parenchyma and simple parenchyma.

The vessels are large, two or three collected and

surrounded by a layer of pitted woody parenchyma containing resin at times. Pitted vessels predominate. The woody fibres are numerous, making up the greater part of the bundle. The woody parenchyma forms tangential bands which are quite a marked feature of this wood. These contain at times calcium oxalate crystals.

The pith consists of large, spherical cells, abundantly pored, containing numerous calcium oxalate crystals.

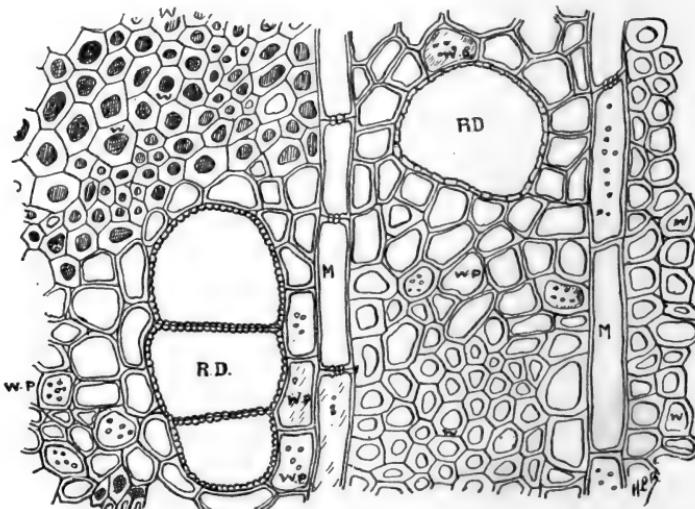


FIG. 38.—CROSS-SECTION QUASSIA.

WP, Wood parenchyma; M, Medullary rays; W, wood fibres; RD, reticulated ducts.

Surinam.—All the elements are smaller, so that the wood seems harder and thicker. The medullary rays are narrower, generally only one, rarely two cells wide, five to twenty cells high; woody parenchyma less; vessels thicker walled. Vessels in groups of two to five; about one-half diameter of distance between medullary rays; pores broader than long. Calcium oxalate not found in wood, but in medullary rays.

Under the low power the stem and branch pieces

show a small one-half inch thick rind. Within is seen the strongly marked whitish yellow woody centre, which shows concentric sheath and narrow vessels and very fine, closely arranged whitish medullary rays. A light brown pith is found in the centre.

With the higher magnification the cortex shows a layer of cork, on cross-section oblong quadrangular, on long section somewhat elongated hexagonal. Within is found a layer of parenchymatic cells rich in calcium oxalate, also a number of stone cells, which at times form a more or less complete sheath separating the outer from the inner cortex. The phloem of the fibro-vascular bundles consists of a few bast fibres, sieve tubes, and parenchyma. They are radially arranged and separated by the medullary rays, which have become somewhat wider than when in the xylem portion of the bundle.

The medullary rays are small, one or two cells wide only. The xylem contains ducts, woody parenchyma, and simple parenchyma.

The woody tissues lie in more or less alternate rows of two or three pitted vessels surrounded by woody fibres and one or two rows of woody parenchyma, pitted with simple pores. There are no annular rings, as the plant is tropical. Pith is composed of polyhedral cells.

Differences.—Surinam, smaller pieces, branches, etc.; Jamaica, blocks, etc.

Surinam, medullary rays one cell wide or only two. Vessels smaller. Sheath of parenchyma in wood one or two cells wide. Smaller sized pieces, never over four inches in diameter. Thin, brittle bark. Denser wood. Crystals present in woody parenchyma (Meyer).

Jamaica, rays two or three cells wide. Vessels double the size. Woody parenchyma two to four cells wide. Large blocks. More open and porous. Crystals in woody parenchyma and medullary rays.

Chemistry.—The main and important constituents of

both forms of quassia is quassin. Besides this, there is some resin and starch. The wood of the Surinam variety yields 3.6 per cent. and its bark 17.8 per cent. ash, while the figures for the Jamaica variety are respectively 7.8 and 9.8 per cent.

HÆMATOXYLON. LOGWOOD.

The heart wood of *Hæmatoxylon Campechianum*, Linné (nat. ord. *Leguminosæ*).

This is a tropical tree, 8 to 12 metres (24 to 36 feet) high, a native of Central America, but since 1715 cultivated in Jamaica and other West Indian islands. The trunks and branches of the trees at least ten years old are collected, and the yellowish sap wood removed.

Description.—The wood comes in logs about three feet long and weighing about 50 kilograms. It is bluish black or greenish externally, fibrous, splitting easily, the fresh surfaces shining red brown. The wood also often occurs in commerce in the form of chips or powder which have been exposed to air and moisture and have assumed a greenish-black color. In this state it should not be used as a drug. The odor is pleasant, the taste sweet and astringent. It colors the saliva red.

Histology.—A cross-section of the root shows in general a number of irregular transverse bands, alternately light and porous and dark and dense. The former form the groundwork in which the unconnected, sinuous, diamond-shaped masses of shining sclerenchymatic wood tissue are embedded. Fine medullary rays divide the whole into equal sections. These are one to three cells wide and contain a red brown pigment. The dense masses are made of long, polygonal, thick-walled, finely dotted wood cells, colored a deep red brown. The porous ground tissue consists of polygonal slightly thick-walled parenchyma through which run the large pitted vessels, singly or in couples. They often occupy the

entire space between two medullary rays. They are filled with red brown masses, as is also the parenchyma, which in addition contains many-faced crystals of calcium oxalate.

Powder.—The color, odor, and taste, all of which are characteristic, are of more diagnostic value than the microscopical characters. It may be distinguished from Brazil wood and Red Saunders by its yielding a purple color with alkalies, whereas Brazil wood causes a red color and Red Saunders remains unaffected. The powder shows, however, the large pitted vessels, the thick wood fibres, and the narrow medullary rays. Calcium oxalate crystals are rare.

Chemistry.—Hæmatoxylon contains tannin, volatile oil, resin, and, as its important commerical constituent, hæmatoxylin. An aqueous solution of the latter yields columnar crystals, which are colorless and very sweet, resembling licorice. By the influence of air and moisture or other weak oxidizing agents these crystals become dark red brown. In solution with ammonia exposed to the air they yield violet-colored hæmatin-ammonia, which at 13°C. yields its ammonia, leaving hæmatin, a blackish-violet crystalline powder with a green lustre. With metallic salts they yield variously colored precipitates. Fused with potash, hæmatoxylin yields pyrogallol.

SANTALUM RUBRUM. RED SAUNDERS.

The wood of *Pterocarpus santalinus*, Linné filius (nat. ord. *Leguminosæ*).

This is a small tree, native of the Coromandel coast, but cultivated in the East Indies and the Philippines. It grows to be about 30 to 40 cm. in diameter and 6 to 8 metres (18 to 24 feet) high.

Description.—Red Saunders is found in the market either in logs derived from the lower portion of the trunk and the larger roots or in chips, raspings, and powder.

The former are irregular, heavy, deprived of bark and sap-wood, 1 m. to 1.5 m. long, 12 to 15 cm. thick, the surface from exposure dark-brown, with a slight greenish tint, internally deep red. The wood is firm, fibrous, susceptible of a high polish, but easily split. It is odorless and tasteless and does not color water.

Histology.—The wood on cross-section reveals alternate bands of dark, dense, and shining tissue and lighter and porous circles. A radial longitudinal section shows a peculiar structure characterized by the oblique directions in which the alternate bands run, crossing each other at an angle of 30 degrees. The wood is divided radially by numerous fine medullary rays into narrow bands.

The wood fibres of the dense bands are long, varying much in diameter, their deep red thickened walls leaving small round or oval lumens.

The light porous bands are composed of two to eight rows of slightly thickened cubical pitted parenchymatic cells containing large crystals of calcium oxalate and masses of red resin. Imbedded in this tissue are the large pitted walled vessels, single or in couples, often occupying all the space between the medullary rays. They are often filled with red resin. The medullary rays are a single cell wide, rarely two-celled, and vertically five to eleven cells high. Their outer ends are curved.

Powder.—The powder is dark red, odorless and tasteless, colored bluish-red by alkalies. It consists mostly of wood fibres, but with some pains portions of the closely pitted vessel walls and fragments of tissue showing tangential sections of the medullary rays may be found. These being but one cell row in width, distinguish this from all other red woods (Moeller). Calcium oxalate crystals are also present.

Chemistry.—Santalic acid or santalin is the principal constituent. Further, pterocarpin and santal and homo-

pterocarpin. Santalin, $C_{15}H_{14}O_2$ or $C_{17}H_{16}O_6$, crystallizes in minute red prisms, insoluble in water, dissolving in alcohol with a red color and an acid reaction, in ether with a yellowish and in alkalies with a violet color. Pterocarpin, $C_{17}H_{16}O_5$, colorless crystals, insoluble in water, with difficulty in alcohol, easily in chloroform and carbon disulphide. Soluble in concentrated sulphuric acid with a red, in nitric acid with a green, color. Santal, $C_6H_8O_3$, colorless crystals, insoluble in water, with difficulty in ammonia water and dilute alcohol, easily in a weak solution of potash with at first a red and then a green color. Ferric chloride turns the alcoholic solution red. Concentrated sulphuric acid dissolves the crystals with a red, nitric acid with a green, color. Homoptero-carpin, colorless crystals, soluble in carbon disulphide.

BARKS.

The subject of barks in pharmacognosy is a much abused one. The vegetable anatomist has one definition of a bark, whereas the pharmacognocist has another. To the one it consists of tissues developed in the main from the layer of primary tissue termed the dermatogen, and comes to be entirely outside of what is known as the phloem portion of the fibro-vascular bundles. To the other, who does not restrict the term so closely, the bark consists of all those structures outside of the cambium line; in this sense, then, being a wider term than that of the anatomist, including both phloem structures and those in the bark proper. Hence the pharmacognocist can rely in great part for the detection of the barks upon the bast fibres, which, according to the anatomical definition, have no place in the bark. The description of the general type of barks here adopted will include both definitions.

In the growing stem anatomists have defined three

regions of growth, the periblem, the plerome, and the dermatogen, from which within general limits the ground tissue, the fibro-vascular bundles, and the epidermis severally take their origin.

Primary epidermis is found in few official barks and is to be seen best in some of the official herbs. In young stems this layer is generally one or two cells thick, the outer cells being cutinized.

Secondary epidermal structures are common. Among the official plants are found the following types.

In the stems of most dicotyledons and a few monocotyledons a series of changes take place which make up the secondary epidermal structures. These secondary changes are brought about by means of what is known as the phellogen layer. As the stem of a plant gets larger the primary epidermis is forced off, and if no other structures grew, the tissues of the plant would suffer exposure; so that while the increase in size is taking place and the primary epidermis is being thrown off a layer of cells immediately beneath the primary epidermis takes on meristematic growth, forming the phellogen layer, and builds up the periderm, adding new structures mainly composed of isodiametric cells on both inside and outside.

The modifications of these isodiametric cells on both inside and outside make up a number of distinct types, the most important of which are the cork cells. These are generally the outermost. Beneath these parenchymatic cells, which may be thickened, stone cells may be found. Within the phloem elements are present.

Hence from the pharmacognostic standpoint the following structures are to be identified and studied: Cork cells; stone cells; bast fibres; sieve tubes, generally lost or dried or otherwise mutilated; simple parenchyma.

CORTEX RHAMNI PURSHIANÆ. CASCARA.

Rhamnus Purshiana (*Cascara Sagrada*).—Chittem Bark. The bark of *Rhamnus Purshiana*, De Candolle (nat. ord. *Rhamnaceæ*). Habitat, northwestern United States.

Description.—Occurs in quills or curved pieces, about 3 to 10 cm. long, and about 2 mm. thick; outer surface brownish-gray and whitish; the young bark having numerous, rather broad, pale-colored warts; inner surface yellowish to light brownish, becoming dark brown with age; smooth or finely striate; fracture short, yellowish, in the inner layer of thick bark somewhat fibrous; inodorous; taste bitter.

The medullary rays are thin and extend about three-fourths of the width across the bark. They occur in groups which converge at their outer ends, thus differing from *Rhamnus Californica*. Stone cells are present, thus distinguishing it from *Rhamnus frangula*. Powdered bark turns orange on the addition of alkalies. *Rhamnus Californica* turns a deep red.

Powder.—The powder shows the following elements: Crystals, starch, resin, cork, bast fibres, parenchyma, medullary ray tissue, stone cells, and fragments of long-celled tissues from the phloem part of the fibro-vascular bundles.

Crystals are the most characteristic constituents of the powder. These are usually in great abundance and are particularly prominent in a fine powder. The rosette forms are the most common; these vary in size, but on the average run about 15 to 20 microns. Cubical crystals are found clinging about the bast fibres in numbers; these are smaller, averaging between 5 and 10 microns in a number of specimens examined.

The starch grains are not of much diagnostic importance, being simple, quite small, and usually inconspicuous. They average in size about 4 microns.

The cork cells are in abundance and are of interest; they vary in size from about 15 to 25 microns and often are found isolated.

Bast fibres are found, in fragments, depending upon the fineness of the powder; they are usually colored some shade of yellow or brown, are about 5 to 15 microns in the

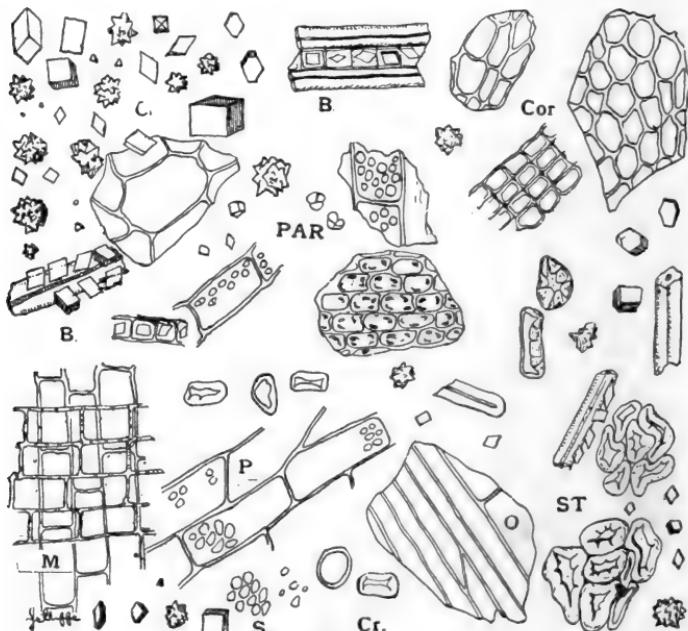


FIG. 39.—POWDERED CASCARA.

C, Crystals, two kinds; B, bast fibre with crystal sac; Cr., Cor, cork; P, PAR, parenchyma with starch; ST, stone cells; M, medullary rays; S, starch; O, tissues of phloem.

short diameter and contain clustered cubical crystals in small crystal sacs, one crystal to a sac, along their long diameter.

The parenchymatic tissues vary widely. Those of the middle bark are usually wider lumened and average about 20 microns in diameter and about 40 microns in length. The cell walls are delicate, those nearer the outer bark

showing the stained walls. The parenchyma of the phloem portion of the bark, the inner bark, is more irregular and contorted, usually due to drying and to hardening of the resin, which seems to be more abundant in this part of the bark.

The stone cells are frequent. They are very irregular and characteristic. In the main, their diameters vary between 25 and 50 microns.

The medullary ray parenchyma is only infrequently met with and presents no noteworthy characteristics. It is usually richly pitted.

The cells from the sieve tube portion of the bark are much distorted, as a rule, but in a field of the whole slide some long thin-walled elements may be found.

Chemistry.—Tannic, oxalic, and malic acids, fixed oil, volatile oils, a neutral crystalline substance resembling frangulin; red, yellow, and brown resins which change to an intense purple on addition of caustic potash.

CORTEX CINNAMOMI. CINNAMON.

SAIGON CINNAMON.

Cinnamomum Saigonicum (Saigon Cinnamon; Ger. Saigonzimmt).—The bark of an undetermined species of *Cinnamomum* (nat. ord. *Laurineæ*), so called from Saigon, in French Cochinchina.

Description.—In quills about 15 cm. long and 10 to 15 mm. in diameter, the bark is 2 or 3 mm. thick; outer surface gray or light grayish-brown, with whitish patches, more or less rough from numerous parts and some transverse ridges and fine longitudinal wrinkles; the inner surface cinnamon-brown or dark-brown, granular and slightly striate; fracture short, granular, in the outer layer cinnamon-colored, having near the cork numerous whitish striae forming an almost uninterrupted line; odor fragrant; taste sweet, warmly aromatic, somewhat

astringent. Saigon cinnamon is darker than Ceylon or Cassia; in thickness it exceeds both, while its taste is the strongest.

CEYLON CINNAMON.

Cinnamomum Zeylanicum (Ceylon Cinnamon; Ger. Zeylonzimmt).—The inner bark of the shoots of *Cinnamomum Zeylanicum*, Breyne (nat. ord. *Laurineæ*). Ceylon.

Description.—Long, closely rolled quills, composed of eight or more layers of bark of the thickness of paper; pale yellowish-brown; outer surface smooth; fracture short-splintery; odor fragrant; taste sweet and warmly aromatic.

The microscopical anatomy of this bark is similar to that of Cassia Cinnamon, except that the elements are smaller, particularly the starch granules, which are mostly about 6 microns in diameter.

CASSIA CINNAMON.

Cinnamomum Cassia (Cassia Cinnamon; German, Cassienzimmt).—The bark of the shoots of one or more undetermined species of *Cinnamomum*, grown in China (Chinese Cinnamon) (nat. ord. *Laurineæ*).

The *Cinnamomum aromaticum* of Nees, *Cinnamomum cassia* of Blume, are the more generally received names for the plant which yields the Cassia cinnamon. This is widely cultivated in the southern provinces of China, between certain latitudes, 22° to 23° , and the bark is usually taken from the six- to ten-year-old trees. The pieces are scraped so that most of the true corky tissue is removed, dried, packed, and shipped in appropriate lengths. The bark from the more delicate stems and the young twigs which are taken from the trees are usually used in China.

Description.—Cassia is found in quills of various shapes and sizes, forming complete tubes or only portions of tubes from 1 to 3 cm. in transverse section and from 25

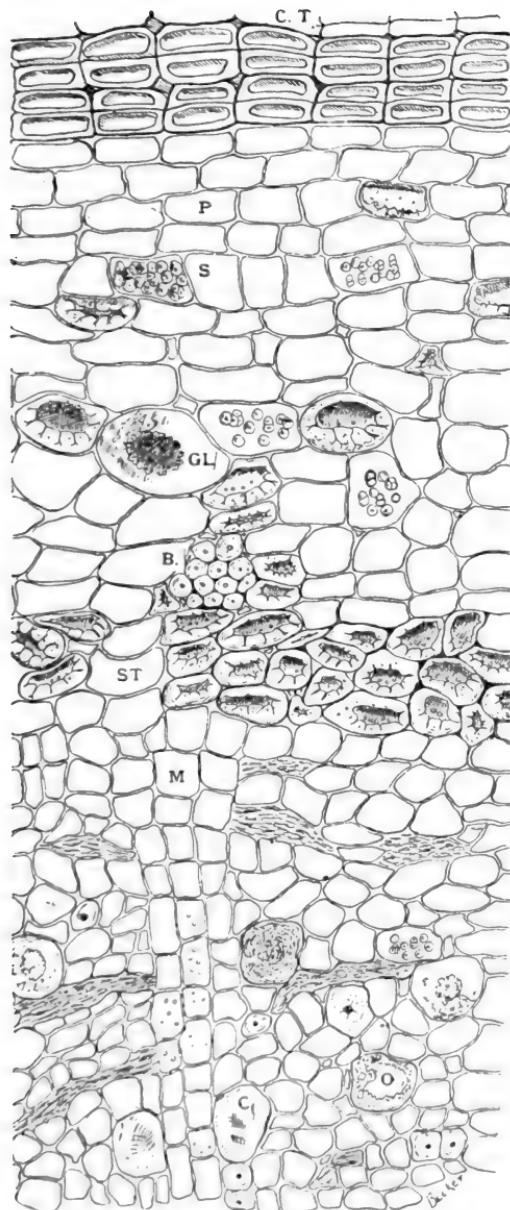


FIG. 40.—CROSS-SECTION CASSIA CINNAMON.

C.T., Cork tissue; P, parenchyma, with stone cells, ST, inter-spersed in outer cortex; S, starch; GL, glands containing oil; B, bundle of bast fibres; M, medullary ray; S, sieve tubes; O, oil cell; C, mucilage cell.

to 40 cm. long. The individual pieces of bark vary from 1 to 3 mm. in thickness.

The inner side is dark-brown, almost to black at times, the outer side is usually lighter—grayish-brown—in its general tone. The differences in the amount of the cork that has been scraped from the outer surface is the cause for the variations in the color. When the cork has been removed entirely, the bark may be reduced to 1 mm. in thickness and have a clear reddish-brown exterior.

The fracture is even, somewhat sharp and short, taste and odor aromatic, at the same time astringent and mucilaginous.

Histology.—With a low power the cross-section is reddish-brown and shows near the centre a strongly refractile white line. On the outer side of this, near the cork, small whitish spots can be noticed, and the inner side shows fine radiating structures with numerous large empty spaces in the inner bark.

Under magnification of from 400 to 600 diameters, the cross-section of the larger and thicker pieces shows on the outside an even, many-layered brownish cork sheath, the outer cork cells having thin walls; the inner, thicker walls, making what is usually called stone cork—the “bork” of some writers. Just beneath the outer bark, the parenchymatic cells of the middle bark are arranged somewhat tangentially. Here and there are found stone cells. These parenchymatic cells are usually rich in starch. Irregular oval mucilage cells are also present in this parenchyma. Marking off the middle bark from the inner bark is a line of mixed stone cells and bast fibres, which under the low power produces the white line. This is not continuous, being broken here and there by numerous thin-walled parenchymatic cells.

The inner bark consists mainly of parenchymatic cells; these are smaller than those in the middle bark and are traversed by the medullary rays, which vary from two to

three cells in width. Bast fibres, single or in groups of two, three, or four, are few in number; mucilage cells are also rare, but large oil spaces are common and characteristic. The sieve tubes are numerous, but for the most part have undergone a keratenchymatous change, being reduced to strings of thick-walled cells, with very small

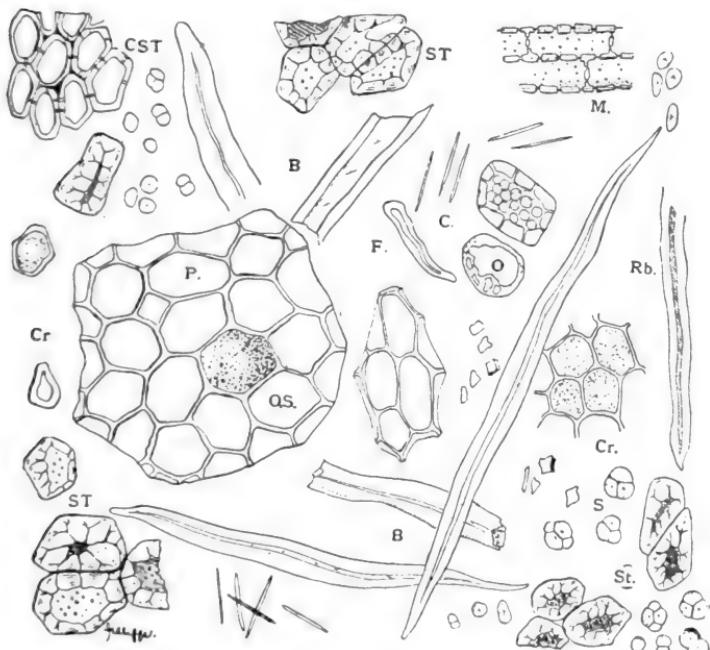


FIG. 41.—POWDERED CASSIA CINNAMON.

St, Stone cells, differing in thickening of walls; CST, cork stone cells; P, parenchyma; O.S, mucus cell; C, crystals; Cr, cork; B, bast fibres; M, medullary ray; F, short fibre; S, starch; O, oil cell; Rb, bast fibre.

lumens. A few crystals may be found in the cells of the medullary rays or in special crystal sacs near the medullary rays.

Powder.—The constituents of the powder are stone cells, cork cells, parenchyma, bast, crystals, and starch.

The stone cells are very numerous. They vary widely both in shape and in the character of their thickening.

Some are almost completely lignified, while others are only slightly thickened, most of them are irregularly spherical to quadratic, slightly tangentially elongated (differing from the Ceylon), and richly pored; the pores are simple, and are usually intricately branched, especially in the more highly lignified cells. A number of the stone cells are irregularly thickened, one side remaining quite thin. This is the inner side, near the cambium. This is an important character in cassia bark, though it is not absolutely diagnostic of the bark, as has been stated by some observers. The stone cells vary in diameter from 10 or 15 to 30 or 40, and sometimes 100 microns. Sometimes stone cells may be found in which starch grains are deposited.

Cork cells are not in abundance, as most of them have been scraped from the bark, yet they are always present in small quantities. They form the characteristic small reddish-brown cell masses, distributed through the powder. Isolated cork cells with slightly thickened walls are present, and also typical stone cork cells. These latter are quite characteristic. They average about 20 to 30 microns, and have partially lignified walls, with straight, simple pores. The lumen is usually filled with dark, reddish-brown masses. The parenchymatic tissue is apt to be irregular, contorted, slightly elongated in the direction of the long axis of the twig. The walls are usually stained a light yellow to deeper brown from the oil which is abundant in the bark. These cells are especially rich in starch, more particularly in the middle bark. They average about 50 to 100 microns in diameter. The parenchymatic cells of the inner (phloem) part of the bark are usually smaller than those outside.

Fibres are conspicuous elements. Two types may be distinguished. Those of the primary bark (middle bark of the pharmacognosist) are in groups, and in the powder are apt to be associated in bundles of 5 or 6 or more.

Those of the secondary bark (inner bark) are usually isolated or in twos; rarely in threes. The diameters of the fibres of the middle bark vary from 8 to 30 microns, while those of the inner bark are more or less constant, 15 to 40 microns, averaging about 35 microns. The length of the two may be the same, 250, 400, 700, but about 500 microns as a general average. The lignification may also be the same. The fibres of the primary bark are apt to be a little longer than those of the secondary bark.

The starch is quite abundant; it is found closely packed in the parenchymatic cells of the middle and inner barks. The grains are both simple and compound. The compound grains consist of two, three, or four granules. The edges are rounded and the hilum is generally centric, simple, or sometimes slightly radiate. The grains average from 4 to 20 microns; the majority measuring about 10 to 13.

In a few cells small acicular crystals of calcium oxalate are found. These are in small quantities only, and are readily overlooked. They rarely are over 5 microns in length. Still more seldom are small cuboidal crystals associated with the fibres. These are also minute, and, while seen sometimes in long sections of the bark, are rarely met with in the powder.

Mucilage cells and oil cells are frequently found. The oil cells are the more prominent. They are situated more commonly in the outer part of the inner bark, and are quite large, being from 20 to 75 microns wide and sometimes 150 microns long. In many of the dried oil cells, small rectangular secretory bodies may be found.

The powder from Ceylon cinnamon shows numerous fibres and stone cells. Parenchyma and starch are not so abundant.

The powder is best studied in chloral or in a 5 per cent. solution of lysol.

Chemistry.—Ethereal oil between 2 and 3 per cent.; tannin, mannit, mucilage, sugar, and ash from 2 to 5 per cent.

Oil of Cinnamon consists of a hydrocarbon, cinnamyl acetate, and 80 to 90 per cent. of cinnamic aldehyde, $C_9H_8O_2$, which takes up oxygen to form cinnamic acid.

CORTEX GRANATI. POMEGRANATE.

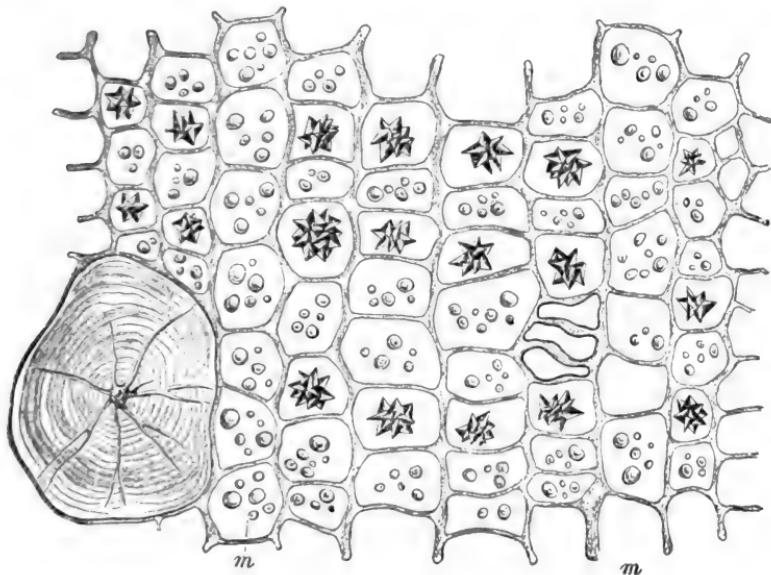
The bark of the stem and root of *Punica granatum*, Linné (nat. ord. *Lythrarieæ*), a plant of India and southwestern Asia; naturalized in subtropical countries.

Description.—In thin quills or fragments, from 5 to 10 cm. long, and from 1 to 3 mm. thick; outer surface yellowish-gray, somewhat warty, or longitudinally and reticulately ridged; the stem bark often partly covered with blackish lichens; the thicker pieces of the root bark more or less scaly externally; inner surface smooth, finely striate, grayish-yellow; inodorous; taste astringent, very slightly bitter.

Cross-sections of the bark, made with a sharp knife, are characteristic in that they appear almost completely homogeneous. The color of the cut surface is yellowish toward the outside, usually somewhat darker than the inner side. On very careful examination the medullary rays may be recognized as very fine dark radiating lines, and the tangential rows or parenchyma cells, in the fibres of the bark, as exceedingly fine cross-lines. In consequence of the lack of long, sclerotic elements the bark breaks short.

Histology.—Only the thinnest pieces of the drug are furnished with a cork layer, since in the first year a cork cambium is produced deep within the primary bark, and later breaks off. Of the primary bark there remains, after the first production of periderm, only the innermost cell deposit of the thin-walled parenchyma, and the primary sieve tubes. Therefore, the cork cambium of the wood bark produces an apparently abundant

periderm. On young, thin pieces of the drug there are here and there, on the outside, thick layers of cork, which consist of increased deposits of thick and thin-walled cork cells, but mostly only of layers consisting of two or four cells, which rest upon a layer of thin-walled cells. The cork cells are seen from above to be irregularly polygonal, but for the most part are quadrangular. In this thickening only the inner wall of the cell takes part,

FIG. 42.—*GRANATUM*.

Cross-section of portion of *Granatum* bark showing large stone cell to left, parenchyma filled with calcium oxalate crystals and starch grains. *m*, The medullary rays, free from crystals (Moeller).

so that it sometimes takes up half the width of the cell; the remaining part of the cell wall is very thin. In young bark there are distinct and regular lenticels; in old bark these are very much flattened out. Next the cork layer there is a layer of phellogen, the cells filled with chlorophyll and starch. Next to the phellogen, and scarcely to be differentiated from it, there is a narrow layer of cells, which arises from the primary bark tissues. After this

comes the irregularly formed outer part of the secondary bark. The secondary bark is penetrated by medullary rays, which are mostly one cell, seldom two cells broad, and from one to fourteen cells long.

In the keratenchymatous strings there usually grow simple, tangential rows of oxalate cells, with small tangential bands of parenchyma enclosing sieve bundles. The similar tangential bands, in the entire bark, are made up of concentric rows. On the tangential or radial sections of the bark it may be seen that the thin-walled oxalate cells are placed together in long rows, or, what amounts to the same thing, they form long chambered or divided crystal tubes. The zones of sieve tube containing parenchyma are made up of rows, two to twelve cells long, of starch-bearing cells, having thickened walls, and of sieve bundles with rather broad, slightly bent, separating walls, and sieve tubes with simple sieve plates.

In old barks a change takes place. The single parenchyma cells of the phellogen, and also those of the bark fibres, increase in size, and their walls thicken, often obliterating their lumen. At the same time, next the sclerenchyma cells, single cells are produced containing oxalate crystals. Later on a formation of cork takes place, which, when the layer of cork becomes about ten cells thick, is broken off.

From the standpoint of the anatomist the root bark varies but slightly from the stem bark. It appears at first as though the bast fibres in the root bark were smaller than those of the stem bark, and that in old barks the elements contained more numerous and smaller stone cells. The very limited thickness of the phellogen layer is characteristic both of young and old root barks; also the absence of the sclerenchyma cells, lying outside of the cambium, and the absence of chlorophyll in the phellogen. In the root bark also the medullary rays extend entirely to the cork layer.

Chemistry.—The principal anthelmintic constituent of the drug is the poisonous pelletierin, $C_8H_{13}NO$, an alkaloid, yet the 20 per cent. of tannic acid contained therein is not without medicinal importance. Besides pelletierin, there are three other poisonous liquid alkaloids—isopelletierin, pseudo-pelletierin, and methyl-pelletierin—found in the bark. The amount of alkaloid seems to vary from 0.1 to 1 per cent., and the various barks seem to give up their alkaloids to boiling water with a varying facility.

CORTEX QUILLAJÆ. SOAP BARK.

The inner bark of *Quillaja Saponaria*, Molina (nat. ord. *Rosaceæ*).

Description.—Flat, large pieces about 5 mm. thick; outer surface brownish-white, often with small patches of brown cork attached, otherwise smooth; inner surface whitish, smooth; fracture splintery, checkered with pale brownish bast fibres imbedded in white tissue; inodorous; taste persistently acrid; the dust very sternutatory. The infusion of quillaja foams like soap-water.

The distinctly checkered arrangement of the tissue which appears on cross-section is due to the zones of sieve-tube groups and parenchyma which alternate with bast bundles and medullary rays. The medullary rays are made up of four rows of cells. The short bast fibres are very much knotted and bent, and contain cavities which enclose crystals of oxalate of lime, of unusual size and structure. In the parenchyma there are, besides the small starch granules, small lumps of a material which is probably saponin. They dissolve in sulphuric acid (sp. gr. 18.4), forming a yellow solution, which changes to red, and then to violet.

Chemistry.—Shaken with water the saponin in the bark produces a lasting foam. Saponin is a poisonous glycoside, formed of two very poisonous substances,

Quillaic acid ($C_{19}H_{30}O_{10}$) and Sapotoxin ($C_{17}H_{26}O_{10}$).

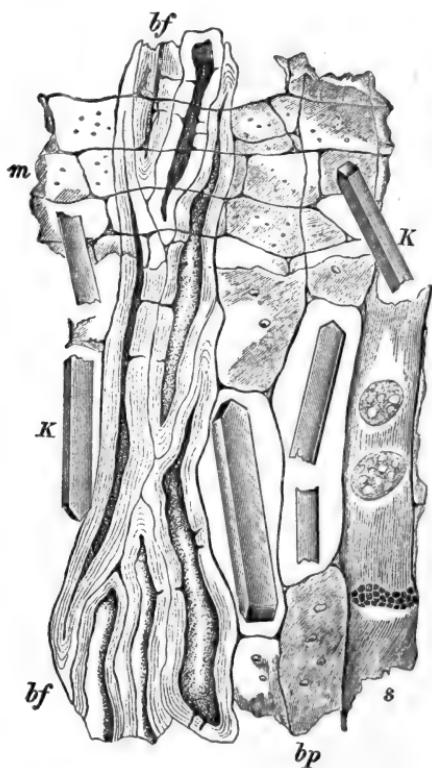


FIG. 43.—QUILLAJA.

Longitudinal section of quillaja bark showing: *K*, Large crystals of calcium oxalate; *bp*, bast parenchyma; *bf*, bast fibres; *s*, sieve tubes; *m*, medullary rays (Moeller).

cause of the irritating action on the nose and mucous membrane (Jacobi).

CORTEX ANGOSTURÆ. ANGOSTURA BARK.

This is the bark of a South American tree, variously named *Cusparia febrifuga*, Humboldt; *Galipea officinalis*, Hancock; *Galipea febrifuga*, Baillon; *Galipea Cusparia*,

Saponin may be separated by boiling alcohol to the amount of 80 per cent., from the powder from the dried watery decoction of Quillaja bark. It is a white, amorphous, and tasteless powder, which does not produce sneezing. It has, according to Stutz, the formula $C_{19}H_{30}O_{10}$.

Saponin is easily soluble in water, insoluble in ether or alcohol. It gives up its contained water only to alcohol. Under the influence of dilute acids it is, on boiling, resolved into sugar and crystallizable sapogenin.

Sapotoxin is amorphous, and easily soluble in water. It gives the burning acrid taste to the bark, and is the

St. Hilare; *Bonplandia trifoliata*, Widenow (nat. ord. *Cusparicæ*).

The tree attains a height of from 4 to 5 m. It is found in the mountains of Venezuela in the neighborhood of the source of the Orinoco River. The drug enters commerce by way of Trinidad.

Description.—The bark comes in irregular, usually slightly curved pieces of various lengths and of a thickness of from 1 to 3 mm. The outer surface is mostly covered by a spongy, yellowish-white cork, warty and somewhat irregularly marked. The bark within is of a reddish-brown color, light, hard and brittle, in thin laminae which often show a shingle-like overlapping appearance on the under side. The fracture is sharp, showing glistening calcium oxalate crystals on the broken surfaces. On maceration in water the bark swells up. The odor is disagreeably aromatic, the taste aromatic, sharp, and bitter.

A cross-section shows three distinct zones. The outer light yellowish periderm, the innermost brownish bast region, which is interrupted by the sharp-pointed medullary rays penetrating into the shining light middle bark. The periderm consists largely of thin-walled, almost cubical cells, between which there may at times be found some stone cells. (Marmé.)

Between the thin-walled parenchyma cells of the outer bark single stone cells lie scattered; also many oil cells, which last are larger than the parenchymatic cells, and contain, in fresh condition, yellowish oil or resin. In this same general region many crystal sacs containing raphides may also be found.

The inner bark contains many parenchymatic cells which contain starch and also crystals. In the inner bark there are also the phloem elements, sieve tubes and bast fibres. The bast fibres are arranged in small bundles. The medullary rays are two or three cells wide, but

become markedly wider toward the periphery. The medullary rays contain starch and oil cells. Oil cells and crystal sacs are to be found in the inner bark also.

Histology.—The periderm is composed of thin-walled cork cells with here and there groups with walls somewhat thickened. The outer portion of the cortical parenchyma is composed of rectangular cells in regular radial files surrounding small and large groups of tangentially elongated stone cells. In the looser and more irregular layer of larger polygonal cells within are distributed numerous large oil or resin cells with yellow contents and still more numerous groups of calcium oxalate raphides with more rarely single cubical crystals. The inner bark with its long well-developed phloem bundles occupies three-fourths of the thickness of the bark. These phloem bundles of layers of regular bast parenchyma, thick-walled where inclosing sieve tube groups, with here and there groups of small thick-walled bast fibres, make up the laminated portion of the bark. The medullary rays, two and three cells wide, expanding outwardly, contain much starch, as does also the bast parenchyma. Here, as in the outer bark, calcium oxalate crystals and oil cells are frequent.

The Powder.—The elements of the powder are the large oval oil or resin cells, surrounded by smaller-celled thin-walled parenchyma, calcium oxalate, rarely in rhomboidal crystals, starch grains, cork cells, sometimes somewhat thickened on the outer side, and occasionally narrow thick-walled bast fibres with simple pointed ends. Numerous groups of irregular thick-walled phloem parenchyma representing the sieve tube portion of the liber are also met with. None of these elements, except perhaps the oil cells, are by themselves particularly characteristic, but altogether they render the recognition of the powder a matter of no great difficulty.

Substitutes and Adulterants.—False Angostura, the

bark of *Strychnos Nux vomica*, which has been sold for Angostura bark in Europe, comes in hard, thick, curved fragments, the outer surface covered with a yellowish cork marked with whitish warts and rust-colored patches. The inner surface is gray and finely striated. A cross-section shows near the surface a dense layer of whitish stone cells forming a continuous layer not present in the true bark. Oil cells and calcium oxalate raphides are absent. The taste, owing to the presence of brucine and strychnine, is very bitter without aroma.

Brazilian Angostura, from *Esembekia febrifuga*, is dark brown on the inner surface, the fracture fibrous, the taste bitter but not aromatic. It is distinguished microscopically by the presence of an abundance of stone cells, distributed in large groups throughout the entire bark.

The bark of *Sternostomum acutatum*, D. C., is distinguished by its smooth exterior surface, by the absence of stone cells, and by the presence of ligneous fibres, in very irregular groups.

The bark of *Alstonia scholaris* is easily distinguished by its peculiar rough, deeply marked, dark gray surface, and microscopically by the presence of milk ducts, the absence of oil cells, and the large lumens of the stone cells.

Chemistry.—The bark contains a yellowish, acrid, volatile oil, 0.75 per cent. starch, resin, and three alkaloids—angosturine, $C_{10}H_{40}O_{14}$, crystallizable, turning red with sulphuric acid and green with sulphuric and nitric acids, its salts yielding a blue fluorescent solution; galipein, $C_{20}H_{21}NO_3$, crystallizing in white needles, yielding soluble greenish-yellow salts; cusparin, $C_{19}H_{17}NO_3$, in greenish-yellow needles, yielding yellow salts. The acetate and tartrate are soluble in water. Treated with potash, cusparin splits up into another alkaloid and an aromatic acid.

CORTEX VIBURNI PRUNIFOLII. BLACK HAW.

The bark of *Viburnum prunifolium*, Linné (nat. ord. *Caprifoliaceæ*).

This is a large shrub or small tree, 2.5 to 6 m. high, growing in the eastern part of the United States from Connecticut to Florida. The bark of both stem and root is collected.

Description.—The stem bark occurs in small, thin, irregular, slightly curved pieces. Outer surface light brown or with irregular patches of silvery white, and blackish, much fissured cork, somewhat warty or showing small black dots. Inner surface smooth, showing minute, glistening crystals (calcium oxalate). The root bark is in much more irregular pieces, lighter in color, outer surface smoother, of an even grayish-brown color, inner surface striated. Both varieties are very brittle. The taste is bitter, more so in the root bark than in that of the stem, and astringent. There is no odor.

Histology.—The cork when present is formed of typical flat tabular cells. The cortical parenchyma is made up of tangentially elongated polyhedral cells rich in agglomerated crystals of calcium oxalate. Distributed throughout are round or oval various sized groups of stone cells with minute lumens and concentrically and radially marked walls. The liber is formed of regularly arranged radial lines of parenchyma. Fibres are absent, but, as in the outer bark, calcium oxalate crystals and stone cells are abundant.

The many indistinct medullary rays one-cell wide, of regular radially elongated cells, divide the inner bark in narrow bands.

Chemistry.—Two bitter resins have been isolated: one brown, proved not to be of glycosidal nature; the other greenish-yellow, slightly soluble in water, freely so in alcohol (Kramer's viburnin). Valerianic acid or

tannin, yielding a greenish-black color with ferric salts, and oxalic, citric, and malic acids are also present.

CORTEX PRUNI VIRGINIANÆ. WILD CHERRY BARK.

"The bark of *Prunus serotina*, Ehrhart (nat. ord. *Rosaceæ*), collected in autumn." U. S.

This is one of the largest of American forest trees, sometimes attaining a height of 100 feet with a trunk three or four feet in diameter. It is found from Hudson Bay south to Mexico, abounding in Kentucky and Ohio. The bark of the root is the most active.

Description.—It comes in irregular pieces, 1 to 3 mm. thick, the thinner the younger, of variable lengths, slightly curved, usually deprived of the rust brown corky layer, greenish, shining, with brown transverse markings. The older the bark, the more the brown predominates. The inner surface is darker, showing white longitudinal striations. The fracture is brittle and granular. When dry it has a faint odor, developing when moistened that of bitter almonds. The taste is bitter, astringent, and aromatic.

Histology.—The cork when present is formed of several rows of brown tabular cells. Imbedded in the cortical parenchyma of thin-walled, polyhedral, tangentially elongated cells are innumerable groups of sclerenchymatic cells closely arranged in radial rows. The individual sclerids are very thick-walled with small lumens, concentric and radial markings. The medullary rays, four to five cells wide, contain, as does the cortical parenchyma, frequent agglomerated crystals of calcium oxalate. The phloem is destitute of fibres, but, like the outer portions of the bark, contains numerous groups of sclerenchymatic tissue, irregular in size and shape. Starch is present in small round grains in bark collected in spring and fall. It fills the cells of the medullary rays and the bast parenchyma.

Chemistry.—Distilled with water, the bark yields hydrocyanic acid and a volatile oil similar to that of bitter almonds. A bitter glycoside, amygdalin, crystallizing in colorless needles, is the source. It is soluble in warm water with a blue fluorescence intensified by alkalies and destroyed by acids.

CORTEX SASSAFRAS. SASSAFRAS BARK.

From bark of root of *Sassafras variifolia*, *Sassafras officinale*, U. S., from Canada to Florida, west to Missouri. Tree. Shrub.

Irregular fragments, deprived of gray corky layer; bright rust brown, soft, fragile, with short corky fracture. Inner surface smooth, strongly fragrant; taste sweetish, aromatic, somewhat astringent.

Histology.—The bark shows on section an outer, thin and compact, brownish layer; an inner loose, brownish, parenchymatic layer, with perhaps a radial appearance in the inner bark.

The outer bark is made up of from five to fifteen rows of regular, oblong, right-angled cork cells. Beneath this there may be at times a portion of the primary bark. This consists of thin-walled parenchymatic cells, large, generally rich in starchy contents.

Scattered here and there in the parenchyma are several large oil cells which contain the active sassafras oil. Crystal cells and crystals are absent. The inner bark is composed in the main of thin parenchymatic cells with a few medullary rays. The medullary rays are generally two cells wide and the cells are more or less quadrangular and possessed of large simple pores. Here and there are a few bast fibres in the outer edge of the secondary bark; these are small in cross-section.

Between the medullary rays lying in the inner side of the inner bark there may be found a few thin-walled camiform cells and perhaps some few sieve tubes. The sieve

tubes have very delicate walls, 0.045 microns in diameter, and in dried specimens are made out with difficulty. The sieve plates are horizontal.

LEAVES.

For the purposes of the general student of pharmacognosy little or nothing need be said regarding the general shape, size, margins, apices, and bases of leaves, but attention is here given to the microscopical characteristics that present themselves in the determination of the leaves that are broken or powdered. Leaf structures are very characteristic.

In order to correctly understand this microscopical structure it will be necessary to recall that in the leaf there are to be found parts of three types of tissues; the Epidermal, the Respiratory, and the Conducting Systems. The surface is mainly made up of the epidermal tissues; the leaf is built up, and around the veins of the leaf, that is, about the conducting tissue, and in between are to be found the tissues of respiration and assimilation.

The Epidermis.—From a diagnostic standpoint this is the most important of the tissues in broken or powdered leaves. The epidermis of leaves is a continuation of the epidermis of the stem, and is found to consist generally of one layer of tissue completely surrounding the leaf surfaces. It consists of isodiametric cells that fit into one another without intercellular spaces. Usually the outer wall of the cells is strongly cutinized, the degree of cutinization varying, as a rule, according to the amount of heat or cold the leaves are called upon to stand. In leaves that are normally horizontal the upper or more exposed side has epidermal cells whose walls are generally more markedly cutinized than are those on the lower or less exposed side.

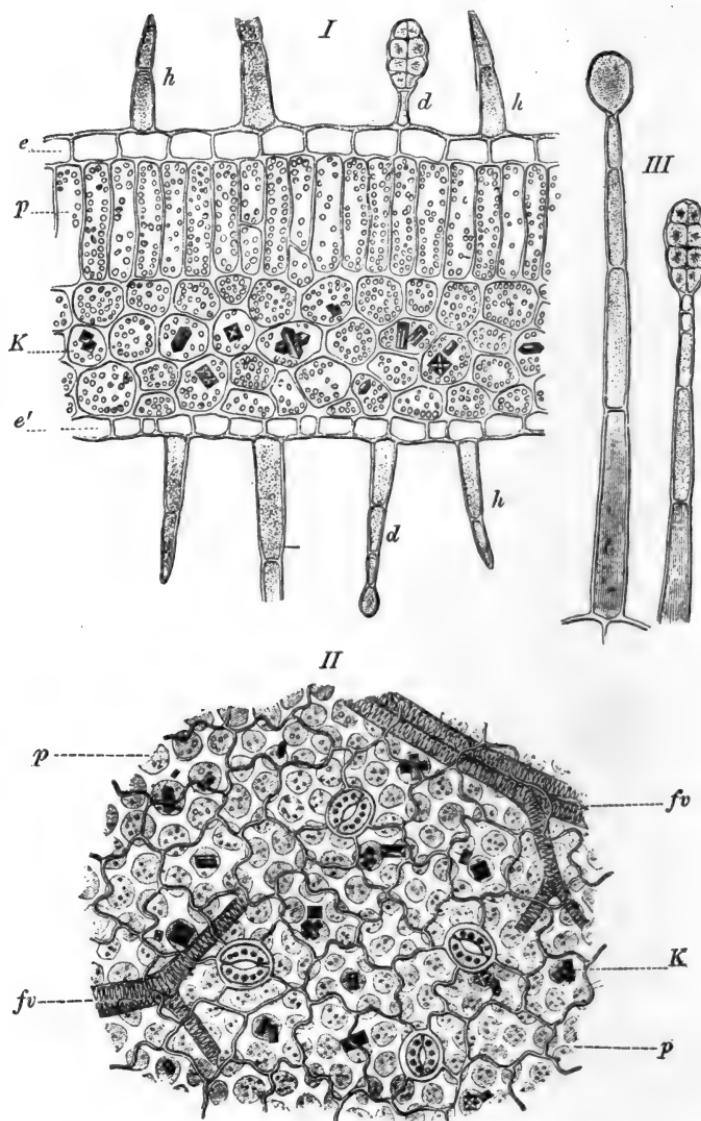


FIG. 44.—GENERAL STRUCTURE OF LEAF.

I, Cross-section: *e*, *e'*, Epidermis; *p*, palisade cells; *K*, crystals in mesophyll; *h*, simple hairs; *d*, glandular hairs. II, Superficial view of leaf: *fv*, Spiral vessel; *p*, parenchymatic cells, with oval stomata and wavy outlines of epidermal cells; *K*, crystals. III, Glandular hairs greatly enlarged.

In the leaves of evergreens that are exposed to extremes of cold this same adjustment is apparent.

The important parts of the leaf from the technical standpoint are, however, the trichomes. These are appendages or outgrowths of the epidermis, and their shapes, sizes, and characteristics are of great importance. Two main types of Trichomes are to be distinguished:

1. Glandular Hairs.
2. Trichomes proper.

Glandular hairs are, properly, hairs that contain secretions. Trichomes proper exist in almost every conceivable variation, from simple papillæ to many branched and shield-like hairs.

Other important modifications of the epidermis are the stomata. These are peculiarly modified cells, as a rule oval to kidney-shaped, on a surface vein between which a space is left for the passage of gases into the cavity beneath.*

FOLIA SENNÆ. SENNA.

Senna is the leaves of *Cassia acutifolia* and *Cassia angustifolia*; plants of eastern and central Africa and India. *Cassia acutifolia* is the Alexandrian senna, *Cassia angustifolia*, the Indian, especially fine qualities of which have received the name of Tinnevelly. This is said to come from Arabian seeds cultivated in southern India.

Description.—The leaves of *Cassia acutifolia* are 3 to 5 cm. long and 9 mm. broad, lanceolate or lance-oval, subcoriaceous, brittle, rather pointed, equally oblique at the base, entire, grayish-green, somewhat pubescent, of a peculiar odor and a nauseous, bitter taste. *Cassia angustifolia* leaflets are from 3 to 5 cm. long and 10 to 15 mm. broad, lanceolate, acute, unequally

* For a more detailed study of the Leaf, consult "Morphology and Histology of Plants," Rusby and Jelliffe.

oblique at the base, entire, thin, yellowish-green or dull green, nearly smooth; odor peculiar, somewhat tea-like, taste mucilaginous, bitter, and nauseous.

Histology.—The cross-section of the midrib shows a woody pith, convex downward, whose vessels are placed in radial, fan-shaped rows. In *Cassia acutifolia* they are separated by broad medullary rows; in *Cassia angustifolia* they are closer together. A small layer of sieve-tissue surrounds the convex margin; this is bordered by several layers of polygonal, lignified cells in the form of a semicircle.

The parenchymatous cells pass over into a collenchyma, which is covered by epidermis and cuticle. Along the upper side of the leaf the woody portion is covered by a plano-convex or elliptical plate, consisting of several layers of polygonal, lignified cells. Following this is a layer of chlorophyll, containing palisade cells, which lie close to the epidermis. In the mesophyll, a loose tissue, containing vascular bundles, crystal sacs, and calcium oxalate crystals, separates the broad upper palisade layer from the narrow lower one. The cells of the epidermis are polygonal, and both upper and lower surfaces are supplied with stomata and warty hairs.

Powder.—This is brownish-green and has a leaf-like and also a peculiar characteristic odor. The following elements enter into the composition of the powder: Hairs, crystals, parenchyma, chlorophyll grains, stomata, and the constituents of the midribs and veinlets, fibres and spiral or annular vessels, and occasionally pitted ducts.

The hairs are characteristic; they vary greatly in size, reaching a length of 300 microns and usually averaging about 25 microns at the base; they are usually sharply bent either at the base or, more often, below the centre; the upper third is minutely roughened.

The cells clustered about the scars and the number of leaf scars found upon a fragment are characters used by

some writers to distinguish the varieties of senna; these have proved inadequate in the writer's experience.

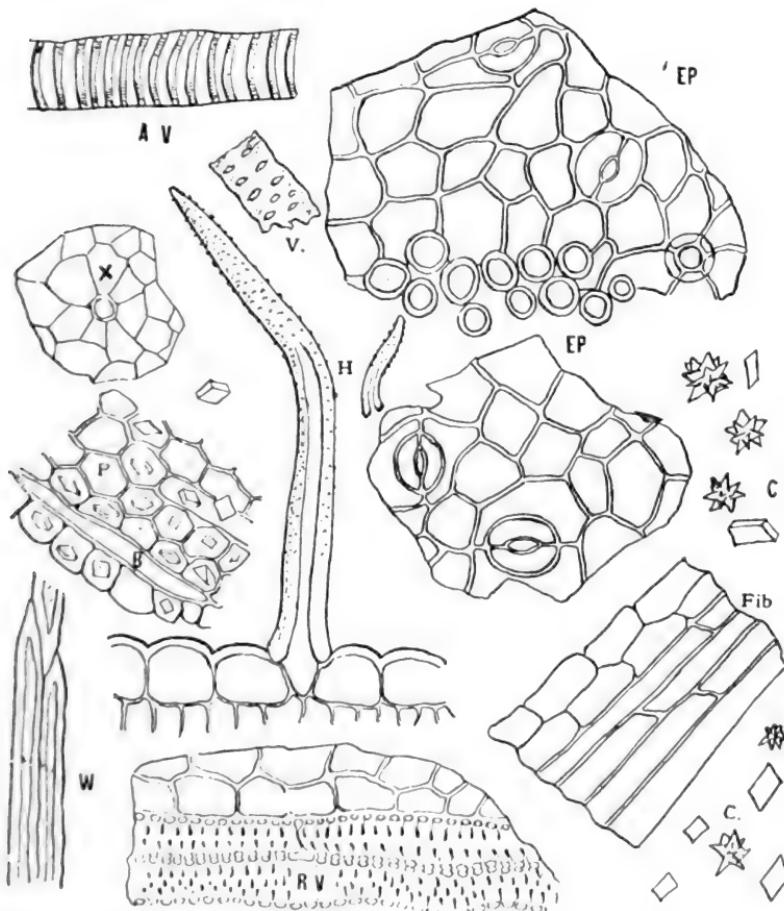


FIG. 45.—SENNA IN POWDER.

C, Crystals; H, hairs, large and small; EP, epidermis, above, showing scars of hairs; P, parenchyma; B, bast fibres; W, woody fibres; AV, annular vessel; RV, reticular vessel; V, pitted vessel; X, epidermis of leaf about a hair; Fib, fibres of phloem.

The crystals are small and at times rare. Two types are observable: flat tabular angular forms and the spherical agglomerative variety.

The parenchymatic tissue is the characteristic mesophyll of leaves; in fresh powders the chlorophyll grains are prominent and numerous. The stomata are held to be characteristic by some writers, but exhibit great variety in form.

The elements of the leaf stalks and veins are usually conspicuous, lying in small masses; the vessels, spiral or annular, are of the usual form; from the midrib or leaf stalk pitted vessels may be found, also a certain proportion of fibres; some short bast fibres may be found in the mesophyll.

Chemistry.—The active principle is probably cathartic acid, a black amorphous glycoside. Besides this, there are sennapicrin, a bitter substance, crystallizable sugar, cathartomannite, and also chrysophanic, malic, tartaric, and oxalic acids, with mucin, tannin, and traces of a volatile oil. The ash constitutes 1 to 12 per cent.

FOLIA DIGITALIS. DIGITALIS.

“The leaves of *Digitalis purpurea*, Linné (nat. ord. *Scrophularineæ*), collected from plants of the second year's growth.”

Digitalis is a handsome biennial herb, 2 to 5 feet high, growing in sandy or gravelly soil in the mountainous forests of Western Europe, from Norway to southern Spain. It is cultivated as a garden plant, and, to some extent, for the drug market.

Leaves of the second year's growth only should be collected. They should be full-grown, gathered at the time of flowering, or, according to F. Schneider, during the late summer or early fall. The preservation of the virtues of the drug requires great care in drying. The leaves become inactive in about one year. The seeds, though little used in the United States, are stronger and more permanent.

Description.—The lower leaves are narrowly oval in

shape, bluntly pointed, the base is decurrent, extending down the sides of the petiole. They measure 20 to 40 cm. in length, 6 to 10 cm. in breadth, with strongly crenulate or crenulate-dentate, sometimes slightly undulate, margins. The upper leaves become smaller and are borne on gradually shorter petioles as they ascend. They are more oblong in shape with less crenulate margins. The upper surface is deep-green, paler in younger leaves, smooth or very slightly pubescent. The lower surface is much paler, grayish, and very hairy, and

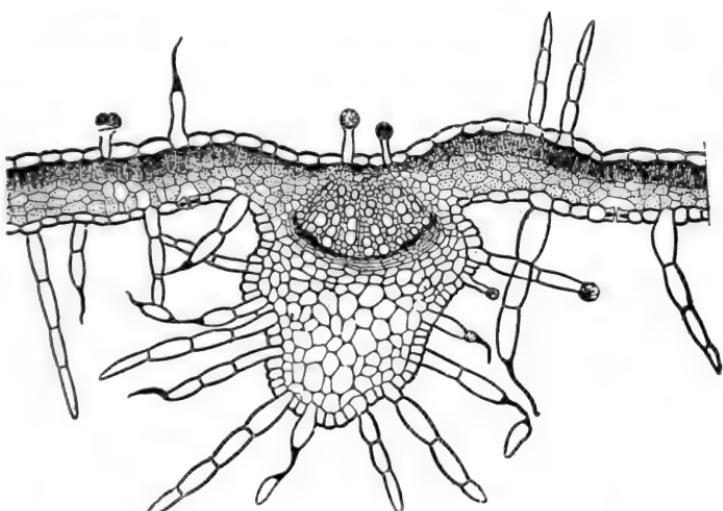


FIG. 46.—CROSS-SECTION OF *DIGITALIS* LEAF SHOWING MIDRIB OF VASCULAR BUNDLE AND HAIRS ON THE EPIDERMIS.

is marked by a network of very prominent whitish veins. The secondary veins leave the midrib, which is quite broad at the base, thence tapering upward, at an angle of about 45 degrees, and, following a somewhat undulating course, diverge to the margins, where they recurve. From them branch numerous tertiary veins, which form the coarse network so characteristic of this leaf.

The odor of the fresh leaves is peculiar and disagreeable; they possess a slight tea-like aroma. In infusion they develop the original disagreeable odor. The taste is acrid and bitter.

Histology.—The upper epidermis of elongated polygonal cells, with sometimes slightly undulating walls, bears here and there simple and glandular hairs, but no stomata. The simple hairs are long, two to four-celled, very thin-walled, the terminal cell bluntly pointed. They show an inclination to turn at the cell-joinings. Often, too, the walls of a single cell are collapsed, while those on either side retain their normal form. The glandular hairs are short, formed of a one or two-celled pedicle supporting a spherical one or two-celled head, containing a yellow resinous mass. The mesophyll consists of a single row of palisade cells and three or four rows of thin-walled, round or elongated parenchyma, loosely arranged, with large intercellular spaces. Calcium oxalate crystals are entirely absent. The structure of the vascular bundle in the primary nerve is bi-convex, formed of radial rows of vascular tissue and a sieve portion, separated by masses of polygonal, vertically elongated, and densely thickened wood tissue. Large-celled parenchyma and interlocked collenchyma occupy the space between the fibro-vascular bundle and the epidermis on either side. The under epidermis is composed of unusually small cells with undulating interlocking outlines. Both varieties of hairs are plentiful. The stomata are also of frequent occurrence. They are small, oval, or often almost round.

Powder.—The most conspicuous element of the powder is the hairs. These, with their extremely thin walls, are of diagnostic importance. Portions of the under epidermis, with their small interlocked cells and stomata, are also noteworthy. For the rest, the fibro-vascular elements and parenchyma are of little value.

The absence of calcium oxalate crystals distinguishes this from all other narcotic herbs.

Adulterations and Substitutions.—*Verbascum* leaves from *Verbascum phlomoides*, L., and *V. thapsiforme*, somewhat resembling *Digitalis*, are thicker and, on the under side, more densely hairy. Microscopically they

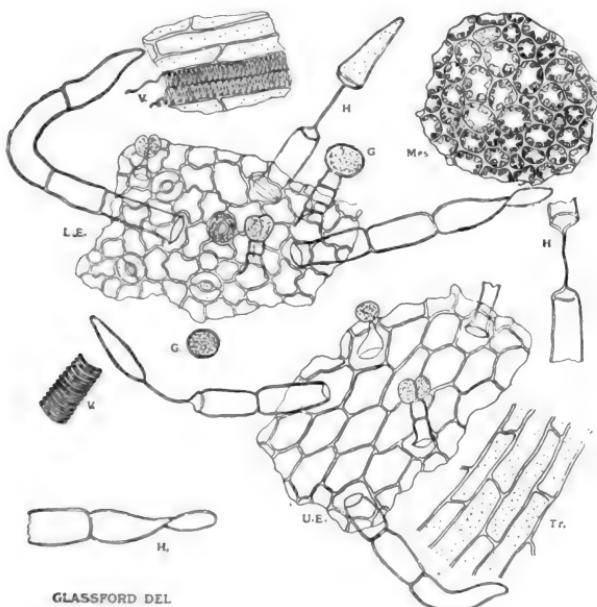


FIG. 47.—*DIGITALIS IN POWDER.*

H, Hairs; G, glands; Mes, mesophyll, seen on end; Tr, tracheids; U.E, upper epidermis; L.E, lower epidermis; V, vessels.

are readily distinguished by their branched star-shaped hairs.

The leaves of *Symphytum officinale*, L., are entire, rough-haired, and without bitter taste; those of *Inula conyzoides*, D. C., are entire or sharply serrate, with thicker-walled hairs than those of *Digitalis* (Moeller).

In powder the drug is adulterated with belladonna, stramonium, and hyoscyamus. All these contain calcium

oxalate crystals; belladonna in the form of fine powder (sand crystals); stramonium, sand crystals and agglomerations; hyoscyamus, large single crystals.

In digitalis, as stated, all forms of calcium oxalate crystals are entirely absent.

Chemistry.—The chemistry of digitalis is complex and as yet incompletely studied. There are in the market a large number of commercial products. The French and German digitalins, however, are supposed to represent the drug. Neither do so completely. Schmiedeberg (1874-75) has isolated four principles, all free from nitrogen—digitonin, digitalein, digitalin, and digitoxin; further, there are present two acids, digitalic and antirrhinic, a stearopten, digitalosium, inosite, and ash, 10.5 per cent. Reduction compounds of the glycosides are common.

Digitonin, $C_{31}H_{52}O_{11}$, is an amorphous glycoside, similar to saponin, readily soluble in water, slightly so in alcohol, insoluble in ether, chloroform, and benzin. Boiled with dilute acids, it splits up into glucose and two amorphous principles.

Digitalein, the existence of which has been questioned by Kiliani, is described as an amorphous white powder, readily soluble in water, alcohol, and ether.

Digitalin, $C_5H_8O_2$, is amorphous or distinctly crystalline, difficultly soluble in water and ether, easily soluble in alcohol. Heated with acids, it splits up into glucose and digitalin-resin. It is the principal constituent of the amorphous French digitalin.

Digitoxin, $C_{21}H_{32}O_2$, crystallizes in needles. It is soluble in chloroform and hot alcohol and ether, not at all in water or benzin. Boiled in alcoholic solution with dilute acids, it yields amorphous toxiresin. Digitoxin, which is the most active of the constituents of digitalis, forms the greater portion of crystalline French digitalin.

Kiliani has more recently shown that there are differences in the contents of these bodies in seed and in the

leaf, and his work has been revised by Cloetta.* Kiliani found digitoxin and digitophyllin and a product allied to digitalin in the leaves. In the seeds he found digitalin and digitonin. Cloetta's results confirm in part only the researches of Kiliani.

Digitalic acid crystallizes in white needles, having an acid taste and reaction, forming soluble salts with the alkalies and alkaline earths. It decomposes readily in the air. Antirrhinic acid is volatile. It is perhaps identical with valerianic acid.

Digitalin-resin occurs in yellowish-white plates of a pearly lustre, smelling like fresh digitalis, and having a nauseous, astringent taste. It is soluble in alcohol and ether; slightly in hot water.

BELLADONNA.

Atropa belladonna is indigenous to many parts of southern and middle Europe, also to middle and southern Asia and South America. It does not thrive well in northern climates. It is extensively cultivated in England, America, and France.† According to A. Meyer,‡ it is not widely cultivated in Germany, but the leaves are gathered from the wild plants of two to four years of age, during the months of June and July. The cultivated plants are made to yield two crops of leaves, in July and in September, after they are at least two years of age. One hundred parts of the fresh leaves yield about sixteen parts of the dried.

Description.—The leaves when fresh are ovate with sharpened apex, narrowed at the base, from 20 to 30 cm. in length and about 10 to 12 cm. broad. The margins are entire and the surface is smooth; here and

* Journal of Pharmacology, 1899.

†For cultivation, see Holmes, Pharmaceutical Journal and Transactions (3), No. 586, p. 237.

‡Wissenschaftliche Drogenkunde, p. 194.

there a few hairs may be seen on the veins of the under side and also on the petiole. In this latter situation they are more numerous and larger. The younger leaves are more abundantly provided with hairs, and these also have

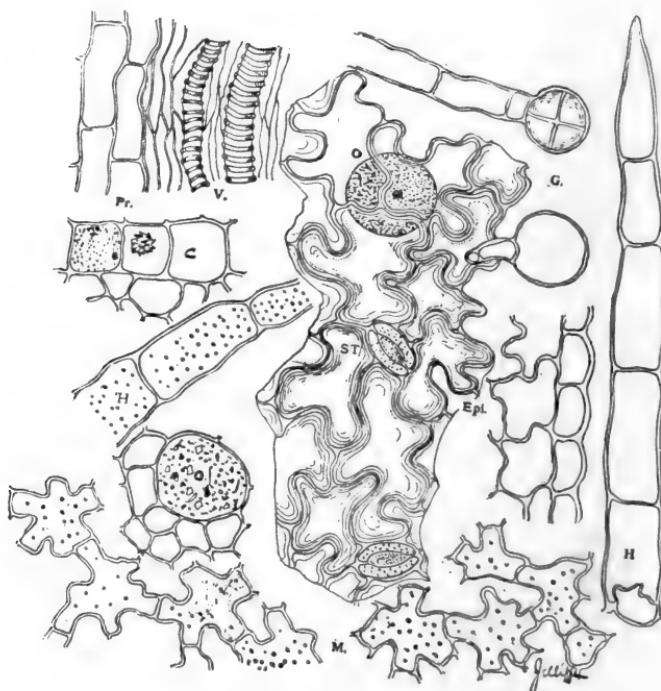


FIG. 48.—BELLADONNA LEAF IN POWDER.

Epi, Epidermis, to right in transverse section; to left, superficial view, showing contorted and wavy cell outlines and the wavy markings of the epidermal cells which are quite characteristic; ST, Stomata; H, simple multicellular hairs; G, glands and glandular hairs; M, parenchymatic tissue of the mesophyll; Pr, parenchyma near the veins, vessels of the ribs and delicate fibre-like elements; C, to left, filled with crystal sand; to right, rosette-shaped crystal; these last being rare; O, parenchymatic cell with crystal sand; V, vessels.

small-stalked glandular cells. The upper surface is dark-green, the lower lighter, grayish-green, showing whitish spots; these locate the cells containing the crystal sand of oxalate of calcium.

Histology.—Both upper and lower surfaces of the leaf

show stomata. These are oval. A cross-section shows the epidermis, with slightly thickened outer cutinized wall, palisade tissues on the upper side only in a single row filled with chlorophyll grains, the mesophyll parenchyma with cells containing the crystal sand and cross-sections of the fibro-vascular bundles, which are more prominent in the lower parts of the leaf.

Powder.—This is brownish to dark green. The most prominent features of a No. 60 powder are the epidermis cells. Other elements are hairs, mesophyll parenchyma, parenchyma of the fibro-vascular bundles, vessels, crystal sand, and rarely crystals.

The epidermal cells are characteristic, they are very wavy and show very delicate wavy markings. The stomata are slightly elongated and have from three to four neighboring cells about them. The mesophyll parenchyma varies. It is in some places isodiametric, in others stellate. Large isodiametric cells imbedded in the mesophyll contain fine crystal sand of calcium oxalate. Larger calcium oxalate crystals of the rosette form occasionally are formed, but these are inconspicuous in the powder.

The hairs are not diagnostic. They are few in number and come from young leaves, on the petioles or under sides of the chief veins in the older leaves. They are usually simple multicellular hairs. Small glandular hairs with short pedicles are also found.

The vessels and fibres are few and not characteristic.

Chemistry.—The chief constituents are atropine, some hyoscyamine, and a trace of belladonnine. According to some, the latter two are identical. Besides these there is present asparagin and 14 to 15 per cent. ash.

HYOSCYAMUS.

Hyoscyamus is the leaf and seeds of *Hyoscyamus niger*. Only the leaf will here be considered. *Hyoscyamus* is

indigenous to many European countries, and is extensively used in gardens.

Description.—The leaf is simple and entire and wilts very rapidly by reason of its open structure. Anatomically it is bifacial, the palisade tissues being found on the upper side only. The epidermis of both sides is similar, and the stomata are distributed on both sides. The epidermis cells are irregular in shape, with wavy outlines save over the main veins, where they are somewhat elongated and sharp pointed. Hairs are present on both sides.

Histology.—The following structures are to be distinguished: Parenchyma, crystals, epidermis cells, hairs, and fibro-vascular elements.

The parenchyma is thin-walled, simple, and usually rich in chlorophyll, often brownish in general color. Palisade cells from the upper side only are in single rows, rarely double, and these usually are connected at their lower ends to the funnel-shaped cells of the mesophyll.

In the irregular mesophyll cells numerous crystals of calcium oxalate are to be found. These are very various—column-shaped, dice-shaped, cuboidal, and octahedral forms being found. Sometimes twin crystals are seen.

The hairs are very characteristic: both simple and glandular types abound. Most of them are multicellular. The simple hairs end in straight non-secreting points, while others have many-celled heads which contain resin-like secretions. The simple hairs vary greatly in length and diameter. In length they often measure from 100 to 400 microns, and often average between 20 and 50 microns at the base. The wall is usually smooth. The glandular hairs may be larger even than the simple ones.

Stomata are frequent, being found on both surfaces. They average about 40 microns in their longest diameter and about 30 in breadth; the “neben-zellen” average three to four, though there may be at times as many as six.

Fibres are not common. Fragments of spiral vessels are not infrequent. Occasionally pollen grains may be found in the powder.

According to Tschirch, the crystals are diagnostic

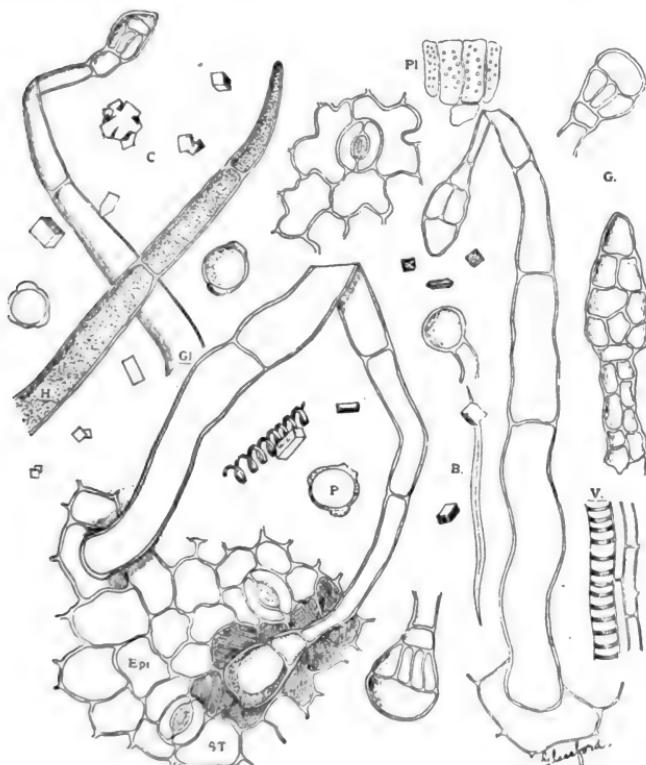


FIG. 49.—HYOSCYAMUS LEAF IN POWDER.

Epi, Epidermal cell with ST, stomata, and Gl, glandular hairs; G, glands from the tips of the hairs; H, simple multicellular hair; Pl, palisade tissue, rich in chlorophyll; C, crystals of at least four shapes; V, vessels from the ribs and petioles; those from the petioles may be reticulated; B, fibre from rib; P, pollen grains occasionally found.

alone and serve as a means of differentiating this leaf from other leaves of the narcotic group. Thus hyoscyamus has at least four kinds of crystals; stramonium has crystal glands; belladonna, crystal sand; and digitalis, no crystals.

Chemistry.—The main ingredients are hyoscyamine, an alkaloid, and hyoscine, also an alkaloid, and some potassium nitrate. The exact composition of hyoscyamine is not yet determined.

PILOCARPUS.

Pilocarpus is the leaflets of *Pilocarpus selloanus* and *Pilocarpus jaborandi*, respectively termed Rio and Pernambuco jaborandis. These plants are low shrubs, usually from four to six feet high, and inhabit the forests and cleared hillsides of Brazil. A large number of species are known, some eight to ten of which have been described as occurring in the markets.* These species are sometimes used as adulterants, and in addition some ten to twelve allied plants have been figured, all of which have at various times been used for sophistication. The plants of the pharmacopœial species are now under cultivation.

Description.—Dried jaborandi leaves are usually greenish-brown in color and oblong-lanceolate in shape, varying from two and a half to four inches. The apex is blunt and emarginate, the margin entire and revolute. The base is usually rounded and unequal and attached to a short stalk. Upon the upper surface the lateral vessels are distinct; the lower surface is glabrous, but sometimes bears a few scattered hairs.

Histology.—The following elements may be identified: Leaf epidermis with stomata, leaf mesophyll, fibrous tissues from the midribs and petioles, oil glands, crystals, starch, hairs, and sometimes stone cells.

The leaves of pilocarpus are dorsiventral; the stomata are confined to the lower surface, hence in the powder upper and lower leaf surfaces are to be differentiated.

The upper epidermal cells are usually regularly polygonal, they vary greatly in average diameter in the

* H. H. Rusby, Druggists' Circular, 1902.

different varieties of jaborandi, and they are usually somewhat wrinkled; over the region of the nerves the walls of the epidermal cells are at times richly pored;

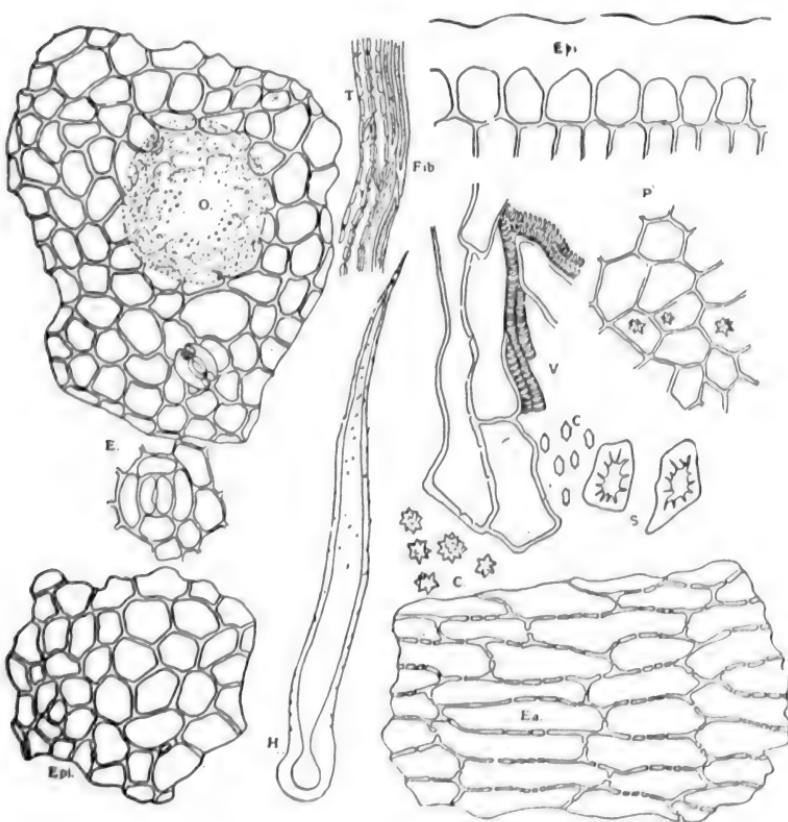


FIG. 50.—JABORANDI IN POWDER.

Epi., Epidermis of upper surface: above, cross-section; below, surface view; E, epidermis of under surface: above, from inside; below, surface view; Ea., epidermis over mid nerve; P, palisade tissue—leaf mesophyll; H, hairs; C, crystals; V, spiral vessels; T, tracheids; Fib., fibres; S, stone cells of petioles; O, oil gland.

the outer cutinized wall is, on the average, thicker in the official leaves.

The stomata vary in the various species; they are confined to the lower epidermal surfaces.

The leaf mesophyll is made up of irregular parenchymatic tissue, some palisade cells with chlorophyll, and many cells contain isolated aggregated crystals of calcium oxalate. A few rhomboid, tabular crystals may also be at times found, though they are few and readily overlooked. The tissues from the nerves and petioles contain bast fibres, few in number; tracheids, a few spiral and annular ducts, and occasionally scalariform ducts.

The oil glands are usually situated just beneath the epidermis of the leaf, either upper or under surface. The crystals have been mentioned as occurring in the mesophyll; starch is usually rare, the granules are, as a rule, simple, rarely compound, with centric hilums, and vary from 6 to 10 microns.

The hairs are very few. They are characteristic, however, long and curved, and are apt to be irregularly thickened towards the apex. Small stone cells sometimes occur in the petiole of the leaf.*

Chemistry. The leaves contain about one-half per cent. of ethereal oil and two alkaloids, pilocarpine and jaborine.

MENTHA PIPERITA. PEPPERMINT.

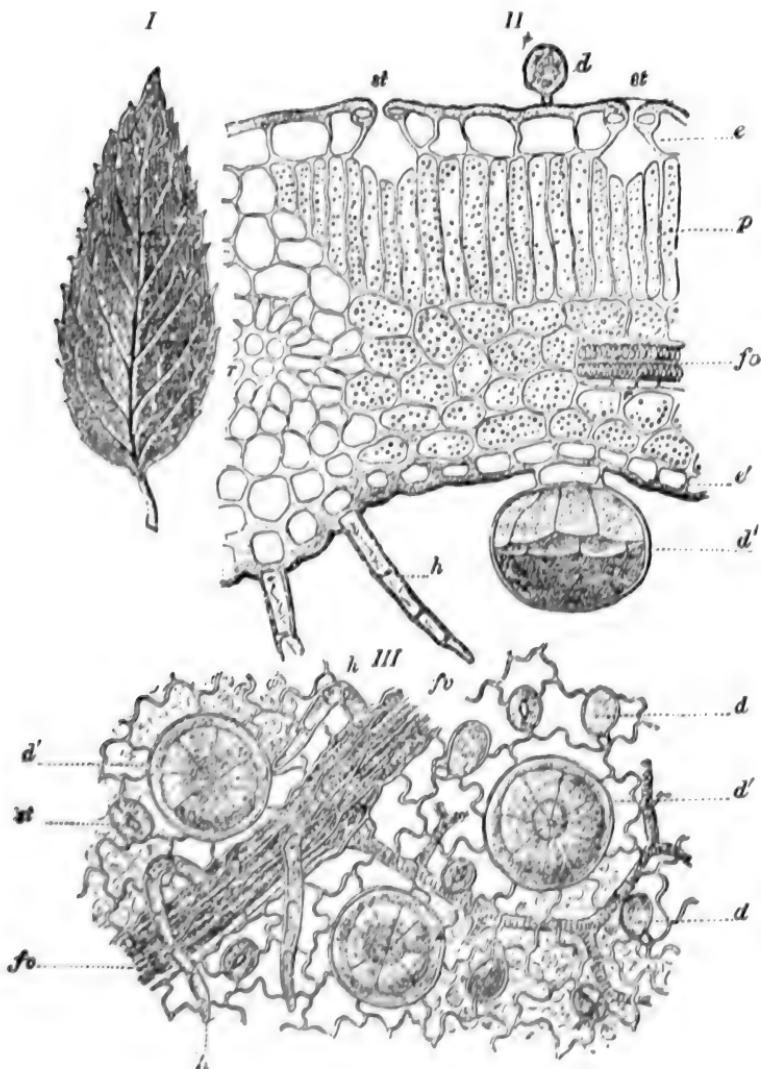
Mentha piperita, peppermint, is the leaves and tops of *Mentha piperita*, a small herbaceous plant widely cultivated in gardens.

Flückiger states † that it does not resemble any known indigenous mint of Europe, and quotes Bentham as stating that peppermint is probably derived from the wild form, *Mentha hirsuta*, L.

Description.—The plant is a low perennial, two to

* Two important researches have recently appeared upon the leaves of pilocarpus, that of Geiger, published in the "Berichte der Deutschen Pharmaceutischen Gesellschaft," 1896, and the other from the Pharmacognosy Laboratory of the New York College of Pharmacy, by A. Schneider, "Journal of Pharmacology," vol. 4, 1897, p. 14.

† *Pharmakognosie des Pflanzenreiches.*

FIG. 51.—*MENTHA PIPERITA*.

I, Leaf of *Mentha piperita*. II, Cross section showing, st, stomata; d, glandular hair; e, guard cell of stoma; p, palisade tissue; fb, fibro-vascular bundle; e', epidermis lower side; d', oil glands; h, hairs; m, midrib. III, Surface view of leaf, letters as in II (after Vogl).

four feet in height. It has a creeping rootstock, from which it sends off long stolons, by which it is propagated, for the most part. The stems are square, erect, purplish, slightly pubescent, and many times branched above. The corolla is light purple, four-lobed, typically bilabiate, with four enclosed didynamous stamens. The calyx is five-lobed, about 2 mm. in length, purplish, and pubescent, with simple multicellular and glandular hairs. The corolla is about twice the length of the calyx.

The drug is made up for the most part of the leaves. These range from 5 to 8 cm. in length and about 2 cm. in width, borne on a petiole about 1 cm. long. They are oval to ovate lanceolate in general outline, finely serrate, minutely glandular, and sparsely provided with hairs.

Histology.—A cross-section of the leaf shows a delicate epidermal layer with a layer of palisade cells, beneath the upper surface; the lower epidermal layer is bordered by open parenchymatic cells, which are richly pored. The oil glands are usually short-pedicelled; short glandular hairs are also present as well as elongated simple multicellular hairs. The cross-section of the midrib or large vein shows collenchymatic parenchyma, open collateral fibro-vascular bundles, with delicate vessels and thin-walled wood fibres and a few bast fibres.*

Powder.—A medium fine powder, is dark green in color, and shows the following characteristic elements: Parenchyma, rich in chlorophyll, simple multicellular hairs, oil glands, sometimes showing menthol crystals within, glandular hairs, ducts, fibres, fragments of floral tissues, collenchyma, and pollen grains.

The parenchyma is usually thin-walled and filled with chlorophyll grains; at times it is richly pored; the average diameter of the cells ranges from 60 to 80 microns.

The hairs are striking; they are thin-walled, usually

* See Tschirch's *angewandte Pflanzenanatomie*, p. 120, Fig. 124.

long and many celled, the walls being marked with fine longitudinal striae. These simple multicellular hairs are non-glandular. They may contain chlorophyll grains or unorganized contents. Small glandular hairs are also present. These are composed usually of two cells,

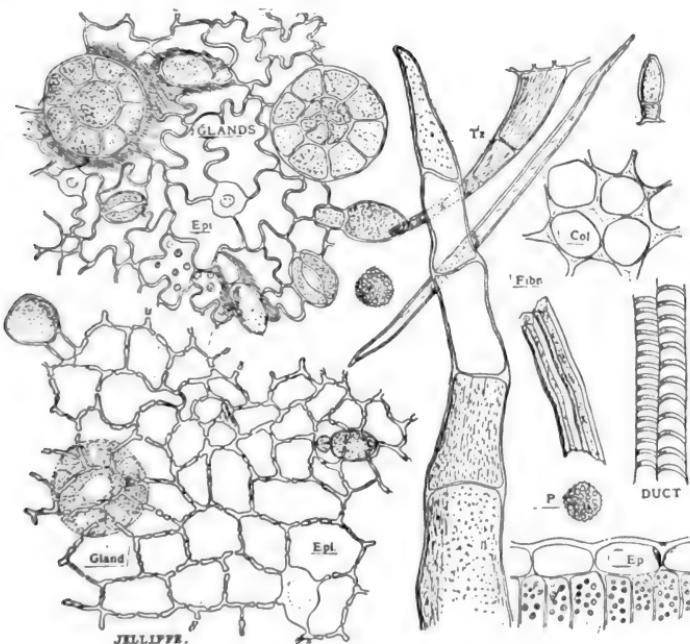


FIG. 52.—MENTHA PIPERITA IN POWDER.

Epi, Epidermis, above, of upper side; below, underneath showing the pitted parenchyma; Tr, hairs or trichomes; Col, collenchyma; P, pollen grains from flower; Ep, cross-section of epidermis showing palisade cells; Fibr, fibres from midrib.

a small quadrangular basal cell and an enlarged pyriform apical cell.

The oil glands are characteristic; they are globose and slightly flattened, multicellular with a short basal pedicel, and filled with oil, in which, at times, crystals of menthol may be present. Their walls are thin, but resistant to evaporation.

Ducts are not common in the powder; they are usually

delicate, and are either annularly or spirally thickened; pitted ducts may be found in specimens which have an appreciable quantity of the stout stems present.

Fibres are also few in number in the powder. Bast fibres are apt to be isolated. Wood fibres are in groups. The walls of each type of fibre are but slightly thickened.

Fragments of delicate, flat tissue, derived from the plant corolla, may be found; these are slightly colored, usually brownish, and readily recognized.

Pollen grains are also not infrequent. The grains are echinate, roughened with minute spines, are globular, sometimes pointed at one side, to ovoid triangular. The surface is undulate, and they average in size, examined in oil, 18.5 to 21.5 by 20 to 21 microns, being almost double the size of the pollen grains of *Mentha viridis*, which, moreover, are distinctly triangular.

Collenchymatic tissues of no particular characters are present; these are derived from the structures of the midrib and the angles of the stem.

Chemistry.—The plant contains resin, tannin, gum, and from 1 to 1.25 per cent. of ethereal oil. The perfectly fresh leaves contain 0.3 per cent. If the leaves are carefully dried, there is little or no loss, as the cuticle of the epidermis and glands does not permit of much evaporation. The ethereal oil is extremely complex, it is greenish yellow, thickens on standing, is soluble in equal volumes of alcohol, specific gravity 0.910, and consists of numerous terpenes, at least fifteen in number, with the general formulae $C_{10}H_{16}$ and $C_{15}H_{29}$; also menthon, $C_{10}H_{18}O$, in which the crystallizable stearopten menthol, $C_{10}H_{19}OH$, is contained.

ERYTHROXYLON. COCA.

Erythroxylon is the leaves of *Erythroxylon coca*. This is a shrub, three to six feet in height, a native of western South America, growing in and about the moun-

tain table-lands. It is there extensively cultivated, and recently also in India, Ceylon, and Java. The leaves are collected from plants over one year of age, and are slowly dried in the sun. Two varieties are commonly found in the market, the Huanuco and the Truxillo.

Description.—The Huanuco leaves have a brownish-green color, are oval in shape, and vary from 4 to 8 cm. in length and from 2.5 to 2 cm. in breadth. Both surfaces are glabrous, and the lateral veins are prominent. The margin is entire, and the lamina tapers toward both base and apex; the latter is acute and the midrib projects in the form of a minute horny point. The odor is faint but characteristic, and the taste slightly bitter.

Truxillo leaves are smaller, pale green, and more fragile, hence usually more or less broken.*

Powder.—This is greenish-brown; if too yellow, it signifies age or imperfect drying. The Huanuco powder is usually darker than that derived from the Truxillo variety.

The main histological elements found in the powder are crystals, parenchyma, epidermis, hairs, vessels, and fibres. The crystals are not abundant; they are of the cubical (monoclinic) variety, usually quite flattened and angular. They are found usually in crystal sacs, one crystal being in each sac, and are present also in the palisade cells; and also clustered about the bast fibres. The average size of the crystals is about 3 to 10 microns. The parenchyma is typical leaf parenchyma. It varies considerably in size, is usually thin-walled, and has on the upper sides of the leaf a single row of palisade cells, rich in chlorophyll.

The structure of the epidermis of the upper and lower surfaces of the leaf is different. The upper surface is macroscopically smooth, though microscopically minutely

* Consult H. H. Rusby, "Coca Leaves," *Druggists' Circular*, 1903.

granular; the walls are regularly and strongly cutinized, Huanuco leaves possessing a thicker epidermis than the Truxillo. The lower surface is provided with stomata, which are thickly distributed. The outer wall of the epidermis on this side is swollen, making small, regular, readily recognizable protuberances. The epidermal cells

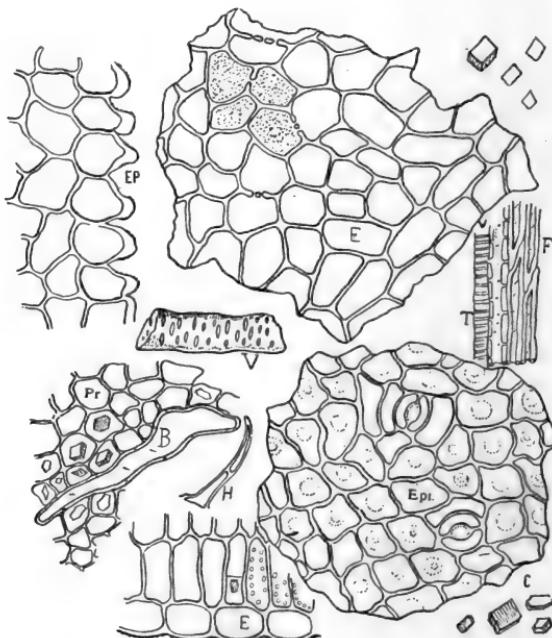


FIG. 53.—COCA LEAF POWDER.

EP, Epidermis, side view, showing papillæ; Epi, epidermis seen from above; Pr, parenchyma; F, fibres; T, tracheids; C, crystals; H, hair; V, pitted vessels; E, lower epidermis, side view below, surface above; B, bast fibre.

of the under side are smaller than those of the upper. The epidermis also has a few simple multicellular hairs; these are few in number and readily overlooked, and are not figured in many illustrations of this powder. The fibres of the petioles, midribs, and veinlets form a conspicuous feature, though not in great abundance. Vessels and fibres are found together. The vessels are of the

spiral annular or reticulated types. The fibres are for the most part comparatively short; those in the Huanuco coca being stouter and stronger than those in the Truxillo. A few starch grains may be found and some oil droplets.

Chemistry.—The important constituents are the two alkaloids, cocaine and hygrine, together with tannic acid and wax.

EUCA LYPTUS.

“The leaves of *Eucalyptus globulus*, Labillardière (nat. ord. *Myrtaceæ*), collected from the older parts of the tree.”

This is a giant tree, native of Tasmania and Australia, but now cultivated in California and southern Europe. It attains a height of 60 or 100 m. and a circumference of 10 to 15 m.

Description.—The leaves are of two kinds; of these, only the older are official. They are thick, 15 to 30 cm. long, about 4 cm. broad, oblique and rounded at the base, borne on long, flat, frequently twisted petioles, in shape falcate, lanceolate, outline entire. Both surfaces are smooth and leathery. Color, greenish-gray, showing, when held to the light, translucent dots of oil-glands. The midrib is slightly prominent, the secondary veins parallel, united at the ends to two undulating marginal veins. The surface is marked with brown dots of suberized tissue. Odor, when bruised, strongly aromatic, camphoraceous; taste pungent, aromatic, slightly bitter.

Histology.—The epidermis, of several rows of strongly cuticulated, flattened cells, polygonal in outline, covering a single row of larger, less thickened cells, in accordance with the vertical position of the leaves on the tree, is alike on both surfaces of the leaf. Stomata are plenteously present on both sides. Within the epidermis are two or three rows of palisade cells, containing chlorophyll. Among the palisade cells near the epidermis are numerous large, round oil-glands. In many places the palisade

tissue undergoes corky modification which results in the brown nodules which break through the epidermis, forming the spots found on the surface of the leaf. The mesophyll, through which run the fibro-vascular bundles, constituting the nerves, consists of somewhat irregular, but far more compact, tissue than is the rule. The cells, as well as those of the palisade layers, contain many crystals of calcium oxalate, both single and in glomerules. The nerves, which are compact and well developed,

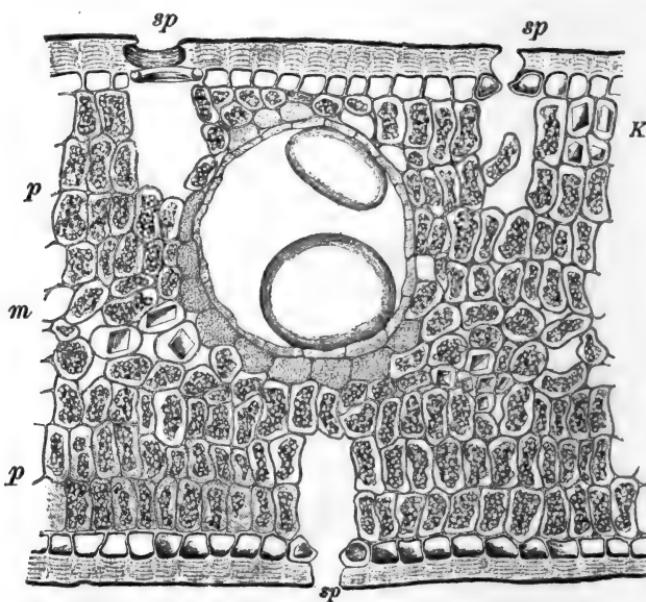


FIG. 54.—*EUCALYPTUS*.

Cross-section of leaf of *Eucalyptus* showing large schizogenous oil cell in the *m*, mesophyll; *p*, parenchyma filled with chlorophyll, palisade cell arrangement; *sp*, stomata; *K*, crystals (Moeller).

consist of wood bundles arranged in regular rows, surrounded by bast fibres which are somewhat thickened on the periphery. The whole bundle is surrounded by a ring of woody parenchyma, which on each side becomes collenchymatic and extends to the epidermis of upper and lower surfaces.

Powder.—In the fresh state the powder is light green. The characteristic elements found are: Epidermal cells, stomata, crystals, fibres, parenchyma, cork cells. The epidermis cells are small, irregularly polygonal, thick-walled. The stomata are broadly oval, present in both epidermal surfaces, superficial. Strongly lignified fibres are present in large numbers, and vessel elements are more prominent in eucalyptus leaves than is usual in other leaves. Both rosette and rhomboid crystals are present in considerable quantities. Collenchyma cells are abundant, and occasionally cork cells are found. These are derived from peculiar lenticels, or wounds, at times found on the leaves.

Chemistry.—The principal constituent of eucalyptus is the volatile oil. This is colorless or slightly yellow, boiling at 170° C., specific gravity 915 to 925, soluble in all proportions of alcohol or glacial acetic acid. It consists principally of eucalyptol (about 70 per cent.); eucalypten and eucalyptolen are also present. The leaves contain also gallic and tannic acid, ceryllic alcohol, pyrocatechin, and a crystallizable acid fusing at 247° C.

BUCHU.

“The leaves of *Barosma betulina* (Thunberg), Bartling et Wendland, and *Barosma crenulata* (Linné), Hooker (nat. ord. *Rutaceæ*).”

Both plants are slender shrubs, about 1 m. high, growing in Southern Africa, in the districts of Clanwilliam and Worcester, north and northeast of Cape Town.

Description.—The leaves of *Barosma betulina* are 10 to 20 mm. long, obovate or almost round, cuneiform at the base, ending in a recurved point, margins serrate, with numerous oil-glands, one in each serration, which render the leaf pellucid punctate. The leaves are thicker than those of the other varieties.

The leaves of *Barosma crenulata* are oblong, oval or

oboval, sometimes elongated, obtused at the apex, from 1 to 2 cm. long and 7 to 10 mm. broad, smooth, with crenulate or serrate margins. At the base of each tooth is situated a large oil-gland. Other smaller glands are distributed throughout the leaf.

These two official varieties yield the short buchu of commerce. Long buchu is obtained from *Barosma serratifolia*, whose leaves are thin, linear, lanceolate, about 3 cm. long, 5 mm. broad, tapering at both ends, margins obtusely serrate, with a gland at each point, apex truncate. All varieties are smooth, dark green in color, paler on the under surface. The odor is strong, peppermint-like. Taste, warm, aromatic, somewhat acrid.

Long buchu is sometimes adulterated with the leaves of *Empleurum serrulatum*. These are longer and narrower than the genuine leaf, apex sharply pointed, margins coarsely serrate. Their odor is distinct, taste acrid.

Histology.—The upper epidermis, destitute of stomata, is formed of a layer of tabular cells with cutinized, thickened outer walls. On the surface, these cells appear polygonal in outline, with straight sides. They are filled with hesperidin. This occurs in irregular yellow masses, amorphous, or in spherocrystals. Beneath the epidermis is a layer of flat cells, rich in mucilage, which swell up on contact with water and elongate in a direction perpendicular to the surface of the leaf. Next within is a layer of typical palisade cells covering the loose, irregular leaf parenchyma. The lower epidermis bears numerous stomata. Hesperidin crystals are also present here. The fibro-vascular bundles are small, but slightly lignified, separated from each epidermis by a number of colorless, thick-walled cells. The oil-glands are large at the borders, occupying the entire space between the upper and lower epidermis. They are enclosed in two layers of tabular, thin-walled parenchyma.

Powder—When fresh the powder is a light green, with

the characteristic odor of the drug. The most important microscopical character is found in the epidermal cells. The stomata are small, somewhat immersed, and numerous. They lie irregularly over the inferior surface. The epidermis cells are regularly polygonal, and many contain spherocrystals as well as irregular rhomboids of calcium oxalate.

Chemistry.—Buchu contains a volatile oil, mucilage, resin, hesperidin, and, perhaps, rutin. The ash is rich in manganese. The volatile oil, 16 per cent., in short buchu, 66 per cent. in the long, consists of a stearopten, diosphenol, having a peppermint odor, and a liquid portion, which by fractionation yields dioscamphor, a substance of a thymol-like odor. The residue yields diosodium.

TEA.

The leaves of *Camellia thea*, Link. (*Thea Sinensis*, Sims.)

Tea is extensively cultivated throughout tropical countries, but the main source of supply is Asia. The leaf is bifacial, the epidermis of both sides being composed of small isodiametric cells. Some are developed into unicellular trichomes 500 to 700 microns in length. The palisade cells are frequently two-rowed, the lower row being much smaller than the first row. The general mesophyll is open and well provided with intercellular spaces. A number of very characteristic sclereids (stone cells) are present in the mesophyll. These are usually very irregularly contorted and twisted and very thick-walled (lignified). They are commonest in old leaves; in the young leaves being associated with the midrib. The stomata are broadly oval with narrow mouth.

The characteristic stone cells and hairs of tea are sufficiently distinctive. Numerous admixtures with other leaves are used for falsification, but for the most part they may be excluded by reason of the absence of the

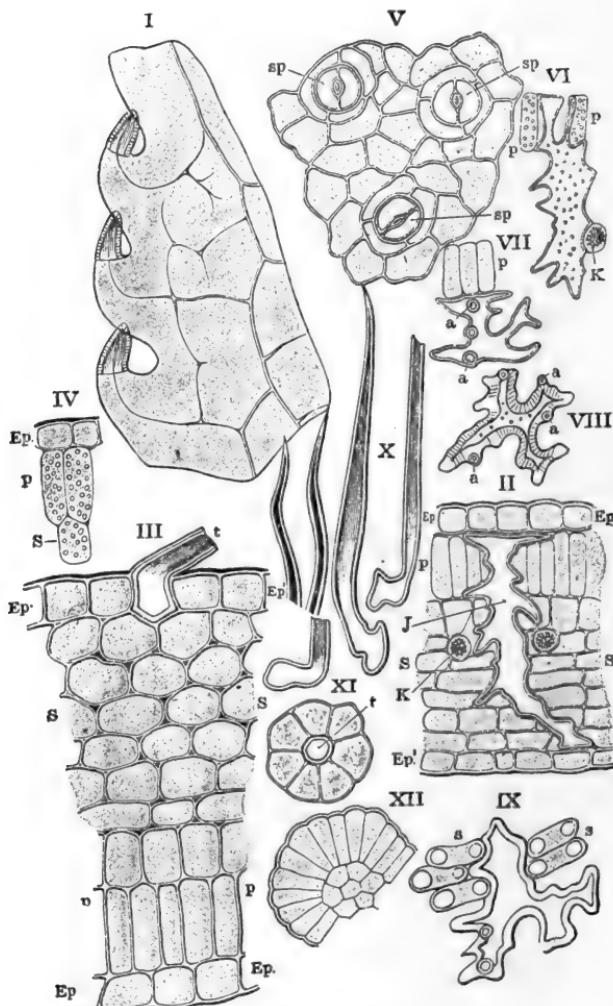


FIG. 55.—TEA LEAVES.

I, Portion of leaf showing the teeth and nerves. II, Cross-section young tea leaf: Ep, Epidermis of upper side; Ep', of lower side; p, palisade cells; S, mesophyll; K, crystals; J, stone cell. III, Cross-section young tea leaf, showing in addition, t, hair. IV, Epidermis, upper side. V, Epidermis from under side, showing sp, stomata; p, parenchyma. VI, VII, VIII, IX, Stone cells and parenchyma with, a, a peculiar thickening. X, Hairs and base of hair. XII, Fragment of gland (Vogl).

typical branched stone cells. Leaves with similar stone cells have been found, and these are frequently used. The Imperial tea of the Chinese is one of these, but in this the stone cells are more regularly oblong, or squarish. The leaves most often used are those of the horse-chestnut, beech, poplar, apple, ash, elder, hawthorne, fire-weed, etc.*

HERBS AND FLOWERS.

The general structure of herbs and flowers does not admit of ready generalization. In the most typical forms the structures of stem, leaf, etc., conform to structures already described under the general headings of leaf and woody structures. In addition, however, herbs and flowers contain cells characteristic of the reproductive organs, pollen and seed structures. These structures introduce a far greater variety into the study of these powders, while at the same time offering more differential characters.

CETRARIA. ICELAND MOSS.

"*Cetraria islandica* (Linné), Acharius (class, Lichens)." U. S.

This is a lichen growing plentifully throughout the temperate zone; in the North, on the plains; in the South, on the mountains.

Description.—The membranous thallus is thin and cartilaginous, 5 to 10 cm. long, obscurely dichotomously divided, the edges of the lobes rolled up below with irregular ciliate margins above. The base is red, the under convex side of the lobes gray with white points, the upper side olive green or brown. The apothecia, seldom present in the dried drug, are 1 cm. broad, saucer-shaped, reddish-brown, situated at the ends of the lobes.

* M. Brunotte: De la determination histologique des falsifications du thé. Thèse Ecole de Pharamacie de Nancy, 1883.

The drug is odorless; the taste bitter and mucilaginous.

Histology.—There are three varieties of tissue. The outer cuticle, four to six cell-rows deep, of very small, thick-walled, difficultly distinguishable cells, with, however, visible lumens, merges into the compact mass of colorless, filiform hyphae, which in turn give way to the dense branched interlocking cells of the central portion. In the latter tissue are numerous intercellular spaces containing round gonidia about 1 micron in diameter,

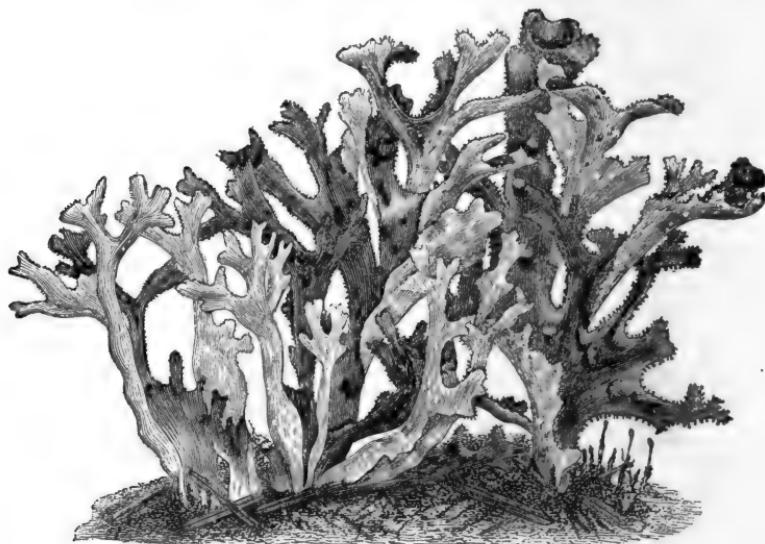


FIG. 56.—*CETRARIA ISLANDICA*.

filled with the green coloring-matter, thallochlor. In many places the colorless middle and outer layers of tissue entirely replace the central body, producing the white dots seen on the surface of the membrane. Here are found crystals of cetrarin. The cilia of the margins are the spermagonia. These are short, cylindrical, often forked, filled with rod-shaped antherozoids, 6 microns long.

Chemistry.—Lichenin or lichen starch, 70 per cent.; cetraric acid, 2 per cent.; lichen-stearic acid, about 1 per

cent., and 1 to 2 per cent. of ash, are the constituents. Lichenin is colorless and tasteless, soluble in boiling water, forming a jelly on cooling. Cetraric acid, or cetrarin, is bitter, crystalline, almost insoluble in water, soluble in warm alcohol and ether; forming salts with bases soluble in water. Lichen-stearic acid is crystalline, insoluble in water, soluble in alcohol and ether.

CHONDRUS. IRISH MOSS. CARRAGHEEN.

"*Chondrus crispus*, Stackhouse, and *Gigartina mammillosa*, J. Agardh (class *Algæ*)."
U. S.

These closely related *Algæ* are found on the rocks on the shores of the Atlantic Ocean, in Europe, from North Cape to Gibraltar; in America, along our eastern coast. They are collected in the spring from the Irish and New England coasts.

Description.—Arising from a disk-like base, the frond of *Chondrus crispus* enlarges and flattens, then either divides dichotomously into numerous linear, slightly wedge-shaped lobes, or into fewer broad irregularly wavy marginate segments. Forms intermediate between these two are also common. The cystocarps are imbedded near the ends of the lobes; they project slightly, sometimes showing a small aperture. *Gigartina mammillosa* is similar but more irregular. The cystocarps, distributed along the grooved branches, are oval and raised on a short peduncle.

Histology.—The two faces of the frond show each a comparatively broad layer of regularly arranged thick-walled cells with minute cavities. Within these are the larger cells of the body of the frond, growing more irregular toward the centre. The contents of these are granular. Zinc chlor-iodide colors the inner lamella of the cell-wall blue, the granular brown, and the mucilage slightly rose-red. The cystocarps consist of large numbers of round or oval well-filled spore sacs.

Chemistry.—The principal constituent is mucilage. One part of this dissolved in thirty of hot water forms a jelly on cooling. It is precipitated by alcohol and lead acetate, is not colored blue by iodine, and in the pure state contains no nitrogen. Boiled with nitric acid it yields mucic acid. Some albuminoids are also present. Fifteen per cent. of ash, mostly sulphates, phosphate, and chlorides; traces only of bromides and iodides.

SANTONICA. LEVANT WORMSEED.

The unexpanded flower heads of *Artemisia pauciflora*, Weber (nat. ord. *Compositæ*).

Alexandria, Aleppo, or Levant wormseed is the product of a woody perennial shrub, about 6 cm. high, growing abundantly in Turkestan and the steppes of southern Siberia.

Description.—The unexpanded flower heads are ovoid, elongated, about 3 mm. long and 1 mm. thick. When fresh they are yellowish-green, becoming brown with age. The involucre is formed of about twelve closely imbricated scales, the inferior ones very small, the superior internally smooth, strongly keeled and bearing many small, shining, resinous glands on the outer surfaces. Their margins are colorless and membranous. The flower heads are separate, shining, and always smooth. This characteristic distinguishes the true from inferior varieties whose flower heads are rendered adherent by the presence of a fine down. (Planchon and Collin.) The involucre encloses upon a naked receptacle three to five undeveloped florets, each divided at the summit into five triangular teeth. The odor is strongly aromatic, the taste bitter and camphoraceous.

Histology.—The epidermal cells of the involucre scales are small, angular, slightly thick-walled, axially elongated. They compose entirely the membranous scale margins, but in the thick central portion they enclose

first an arc of two rows of sclerenchymatic cells which form the keel, and within a body mass of chlorophyll containing parenchyma, through which runs a small central fibro-vascular bundle of concentric structure, the central vessel portion of spiral-annular ducts surrounded by smaller thinner wall liber and the whole enclosed in distinct endodermis. There is usually present a secretory canal smaller than the fibro-vascular bundle. On either side of the keel is a row of large, several celled oil glands. These are similar in structure to those of the *Labiatae*. They are more numerous in the true than in other varieties of the drug. In the neighborhood of these glands are found organic crystals soluble in ether. Calcium oxalate needles are also present. The flower tissue, consisting principally of corolla, bears many similar glands situated in depressions in the lobe. Within the thick-walled epidermis of the corolla lobe are two rows of palisade cells. Within run several minute fibro-vascular bundles.

Powder.—The elements of the powder are numerous, the most frequent being three-sided, almost globular pollen grains. Glands from the bracts and floral leaves are frequent. Long, irregular, pointed stone cells from the keels of the involucre scales, fibres, annular ducts, and parenchyma from the fibro-vascular bundles, portions of pitted walled epidermis with many stomata and irregular cubical organic crystals make up the rest of the powder.

Chemistry.—The active principle of Santonica is santonin, 1.5 to 2 per cent., in colorless prismatic crystals, turning yellow in the light. They are slightly bitter, almost insoluble in water, dissolve in alcohol and ether, and form crystallizable salt with alkalies. Three per cent. of a thin, yellow, unpleasant smelling volatile oil, boiling at 170° F., resin, etc., are also present.

CUSSO. KOUSSO.

"The female inflorescence of *Hagenia Abyssinica* (Bruce), Guieli (nat. ord. *Rosaceæ*)."

This tree, growing on the plateaus of Abyssinia, attains a height of 20 m. It flowers in the autumn. The female panicles are collected and rolled into bundles, 30 to 40 cm. long and 5 cm. thick. It enters commerce through the ports of Aden, Bombay, and Leghorn.

Description.—The inflorescence is in unisexual axillary panicles, about 30 cm. long. The flowers are small, 5 to 10 mm. broad, supported on short pedicles. The branches of the rachis divide dichotomously, bending sharply at each fork. A sheathing bract subtends the base of each branch, and two oboval bracts accompany each flower. All parts are densely hairy and glandular. The short calyx tube of the female flower is surmounted by two whorls of four or five calyx lobes; the outer, 5 to 6 mm. long, membranous, with anastomosing veins; the inner, smaller, about as broad as long. The bracts and calyx are reddish or purple. The petals, usually wanting in the dried drug, are small, linear, lanceolate, alternating with the sepals. The stamens, about twenty in number, are inserted on the calyx tube; each bears a sterile anther on a short filament. Carpels two, one often undeveloped, free, within the calyx tube, bearing on lengthened styles two truncate stymes.

In the male flower the androecium is well-developed, the long filaments bearing two-celled anthers. The gynæcium is abortive. The bracts and calyx are green, with a slight reddish tint. The odor is pleasant, tea-like. Taste, at first mucilaginous, then acrid, bitter, and astringent.

Histology.—The bracts and calyx lobes bear an epidermis of polygonal cells, somewhat thick-walled on the bracts, thinner-walled, with undulating outlines on the

calyx lobes. Stomata and trichomes are numerous. The latter are of two kinds, the one simple, pointed, single-celled, thick-walled, on the leaves, large; on the calyx smaller. The other variety is short, bearing glands, consisting of small many-celled or large single-celled heads, supported on short pedicels. On the bracts, a layer of palisade cells lies beneath the epidermis. The mesophyll consists of star-shaped cells, with large inter-cellular spaces. The peduncle bears an epidermis of finely striated cells. The elongated parenchymatic cells within, enclose agglomerated crystals of calcium oxalate. A few tracheids are also present. The tissue of the anthers is recognized by the regularity of the arrangement of the cells and the reticulate thickenings of the walls. The surface of the stigma is papillous.

Powder.—The elements of the powder are numerous; the most predominant being the trichomes, which vary greatly in size. Spiral and pitted vessels from the peduncle are frequent. The characteristic, usually four-celled, glands are less often met with. For the rest, stone cells from the peduncle, calcium oxalate crystals from the leaf parenchyma, and epidermal tissue, are of little importance. Pollen grains, if present in large numbers, indicate the admixture of male flowers; their occasional occurrence, however, does not indicate fraud.

Chemistry.—Cusso contains a bitter resin, a trace of volatile oil, 24 per cent. of tannin, traces of valerianic and acetic acids, and koussine, which Liechsenring claims to consist of protokosine and koussotoxine, the former crystalline and inactive, the latter amorphous, yellow, fusing at 80°, soluble in alcohol, ether, and chloroform, insoluble in water. Whether koussotoxine or the bitter resin is the active principle is not yet finally determined.

PYRETHRI FLORES. INSECT FLOWERS.

The flowers of several species of *Chrysanthemum*, nat. ord. *Compositæ*.

The product of *C. cinerariæfolium*, Visiani, growing both wild and under cultivation in the mountains of the eastern shores of the Adriatic, and cultivated in California, is called from its original source Dalmatian insect flowers. *C. roseum*, Web. and Mohr, and *C. carneum*, Weber, growing in the Caucasus Mountains and in northern Persia, yield the inferior Persian or Caucasian insect flowers.

Description.—The flower heads of all three species are hemispherical, from 12 to 20 mm. in diameter with a densely imbricate involucre, naked receptacle, ligulate pistillate ray, tubular perfect disk florets, ribbed fruit, toothed pappus.

The bracts of the Dalmatian flowers bear slight whitish scarious margins. There are only about 15 ray flowers present, and the achenes are five ribbed. The pappus is about 1 mm. long.

The Persian flowers bear brown bordered bracts, 20 to 30 rose-red ray florets, and 10 ribbed achenes. The pappus is short, about 0.5 mm. Of the two Persian varieties the rarer product of *C. carneum* may be distinguished from *C. roseum* by the paler ray florets, the less pronounced colored bract borders, and by the extending of the anthers outside the corolla tube of the disk florets. The closed flower heads are more valuable than the open ones, as the development of the flower weakens its efficacy as an insecticide.

Histology.—The upper portion of the stem, which is included with the flowers, bears an epidermis of irregular polygonal cells with numerous stomata, hairs, and glands. The hairs are T-shaped, the long double-pointed horizontal cell often broken off, being supported on a

two- or three-celled pedicle. The glands are elliptical, about six-celled, three rows of two cells each superimposed. This portion of the flower is rich in vascular elements, spiral annular ducts being numerous. The disk is composed of polygonal, thick-walled, much pitted

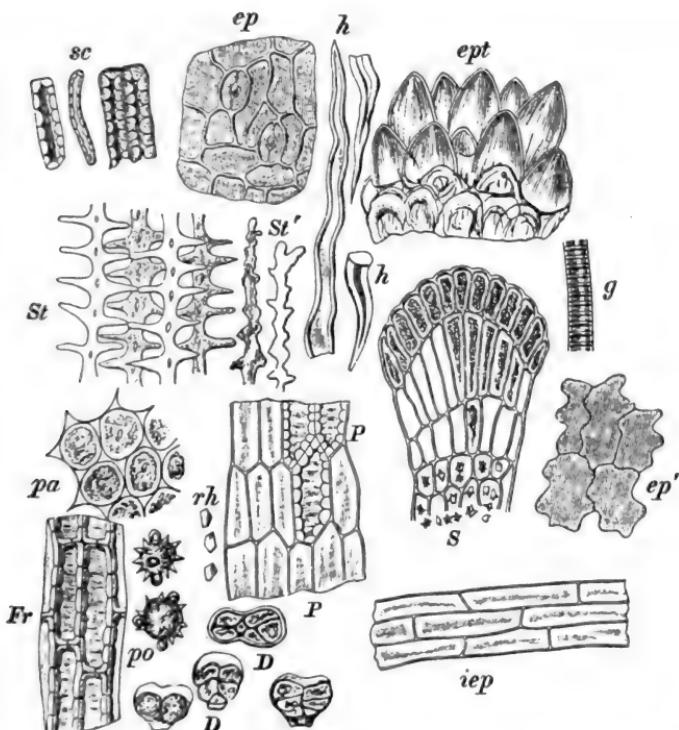


FIG. 57.—PYRETHRUM FLORES.

Insect powder: *sc*, Stone cells; *ep*, epidermis; *h*, hairs; *ept*, epidermis with papillæ; *St*, *St'*, tissue of flowers; *g*, vessel; *pa*, parenchyma; *po*, pollen grains; *P*, cells of pappus; *D*, glands; *S*, portion of flower; *ep'*, epidermis of flower; *iep*, cells of interior of flower and stems; *Fr*, stone cells of fruit; *rh*, rhomboid crystals (Hanausek).

sclerenchyma. Bracts bearing thick-walled epidermis over keel, thinner toward margins and on inner surface, stomata numerous. Within through a loose parenchyma runs a single fibro-vascular bundle with a dense layer of bast fibers, extending into the margins. The ligulæ of

the ray flowers bear an epidermis papillose above, of finely striated polygonal cells below. Glands are found among the striated cells on the lower portion of the ligula; within are several small fibro-vascular bundles, and an occasional oil or resin duct. The elongated disk florets, their lower portion (*Fruchknoten*) enclosed in an entire pappus, densely studded with resin glands below and with numerous crystals of calcium in their elongated, slightly thickened cells, possess a five-toothed corolla of structure similar to that of the rays, but without papillæ. Resin glands and calcium oxalate crystals are frequent. The united anthers are made up of regular polygonal somewhat thick-walled tissue, containing a yellow granular matter. The peculiar thickening of these cell walls is quite characteristic. The round, single-celled pollen grains, 28 microns in diameter, show three distinct equidistant dilations and a surface covered with conical papillæ.

The stigma is forked and bears cylindrical papillæ. The ovary is five-ribbed (in *C. roseum* ten), with a minute fibro-vascular bundle and two or more resin ducts in each, and, in the outer portion, crystals of calcium oxalate.

Powder.—The powder, if unadulterated with curcuma, has a grayish-yellow color. That from the Persian flowers is lighter than that from the Dalmatian. Differential characters are difficult to find. The T-shaped hairs seldom occur with the horizontal cell attached. As they are more numerous on the stem and leaves of the plant than on the flower, their frequent appearance would indicate adulteration, which may be confirmed by the presence of much fibro-vascular tissue and a scarcity of pollen grains. The cell walls of the anthers, at least of the Persian flowers, show peculiar papillous thickenings, which are characteristic. The papillæ on the ligules of the ray flowers of *C. roseum*

are more pronounced than in the Dalmatian variety. The calcium oxalate crystals differ also. Those of the former are imperfect small agglomerations, whereas those of the latter are large, quite perfect single or twin crystals.

Adulteration with Hungarian or Russian daisy may with difficulty be detected by the presence of the trichomes peculiar to the latter. These are long, three to ten-celled, with a much inflated terminal cell. Other adulterants are numerous, among them the flowers of *C. Parthenium*, *C. inodorum*, *C. corybosum*, *Leucanthemum coronarium*, *Anthemis arvensis*, *A. Cotula*, *A. tinctoria* and *A. nobilis*, *Inula pulicaria*, *Tanacetum vulgare*, *Matricaria*, *Calendula*, are difficult to detect. Curcuma, sawdust, and mustard are easily recognized, and chrome yellow, barium chromate, and ochre are discovered in the ash, which should not exceed 7 per cent.

Chemistry.—The active insect-killing constituent has not been determined. Volatile oil, resin, cholesterin, a paraffin, a glycoside, an alkaloid, and three acids, one volatile, have been found.

LAVENDER.

The unexpanded flower of *Lavandula vera*, De C. (nat. ord. *Labiateæ*), a plant of southern Europe; now extensively cultivated.

Description.—Bracts rhombic-ovate, pointed, brownish and glandular; calyx tubular, about 5 mm. long, hairy and glandular, blue-gray, thirteen-ribbed, five-toothed; the upper tooth is more developed, darker colored. The corolla is violet-blue, dries often to a brownish color; about 10 mm. long, on the outside hairy and glandular; two-lipped, the upper lip has two lobes, the lower lip is smaller and has three lobes; stamens four, didynamous, short, inserted on the corolla tube, not extending out of the corolla tube. The corolla is traversed by numerous vascular bundles, and is covered with

fine branching hairs, between which there are also glands. Odor fragrant; taste bitter, somewhat camphoraceous.

Constituents.—About 2 or 3 per cent. of volatile oil.

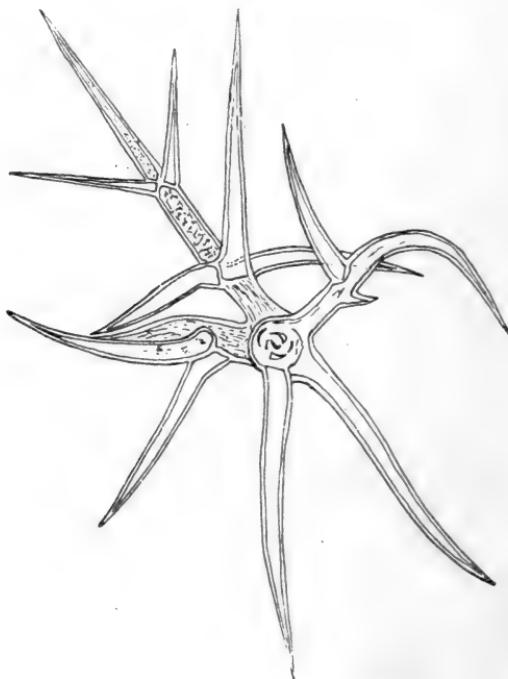


FIG. 58.—HAIRS FROM LAVENDER.

CANNABIS INDICA. INDIAN HEMP.

Cannabis indica is the flowering tops of the female plant of *Cannabis sativa*, L., growing in the East Indies. This is a plant usually some eight to ten feet in height, indigenous to parts of Persia and Asia, and widely cultivated in the Eastern countries.

Description.—The drug usually appears in the shops in flat, compressed masses of a dull greenish color. The tops vary in size from 5 to 30 cm., and consist of straight stems, with ascending branches, longitudinally furrowed and bearing numerous small curved hairs and occasional

glands. The former are enlarged at the base and contain cystoliths. The leaves are alternate, the lower are digitate and consist of three or five linear-lanceolate leaflets with distinct serrated margins; the upper are simple. The pistillate flowers consist of a single ovary surrounded by a perianth and supported by an ovate bract beyond which two long brown stigmas protrude. The fruit is ovoid, slightly reticulated and contains a

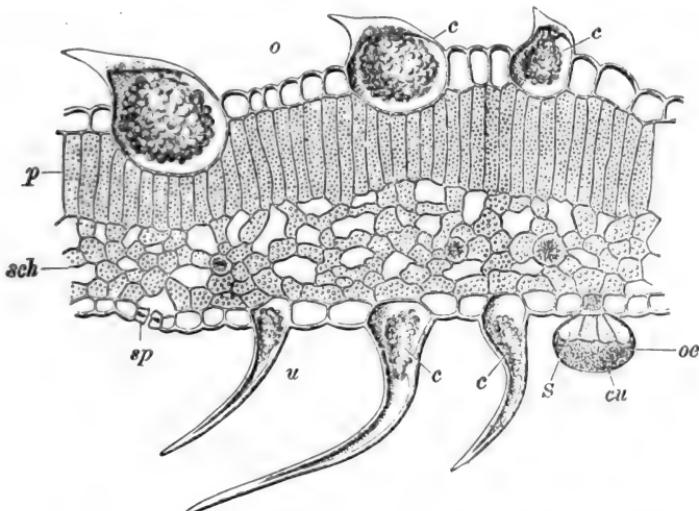


FIG. 59.—LEAF OF CANNABIS INDICA.

p. Mesophyll; *c*, calcium carbonate crystals; *sch*, loose parenchyma; *oe*, oil glands, with *S*, basal cells; *cu*, covering of gland; *sp*, stomata; *o*, upper surface; *u*, under surface; *c*, cystoliths; hairs.

single, oily seed. Both bracts and leaves bear numerous hairs and stalked glands, the latter secreting a viscid resin. The odor is strong, but taste is almost absent.

Histology.—The upper surface of the leaf shows flat, polygonal cells, the lower surface epidermis cells with numerous stomata. Both surfaces are covered with spine-like hairs, set between elevations of the epidermis. They contain a cystolith in a vesicular space and are longer at the lower surface. Small gland-

ular hairs with one-celled stalk and two to four-celled heads and large oil and resin glands are very abundant. On section, the palisade tissue is twice as thick as the spongy tissue; both are rich in calcium oxalate. A horseshoe-shaped woody pith is contained in the midrib, consisting of radially arranged vascular channels. The perianth carries glands and long, thin-walled hairs.

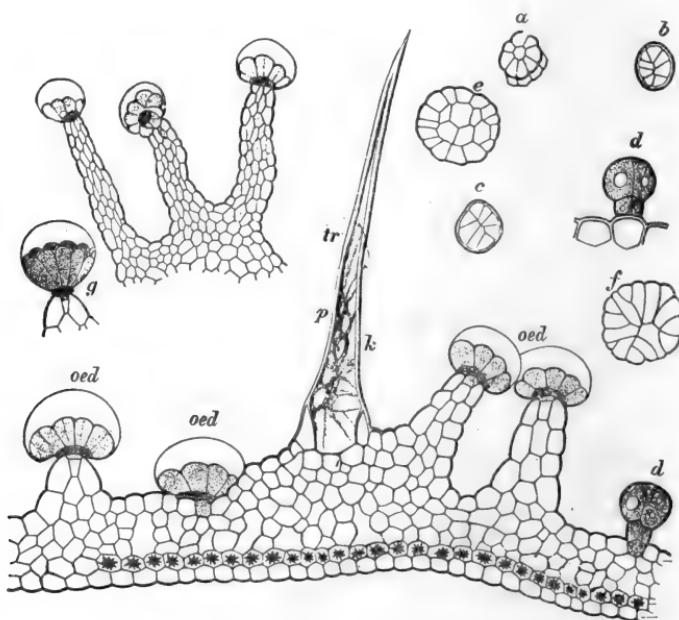


FIG. 60.—*CANNABIS INDICA*.

oed, Oil glands; *tr*, hairs; *d*, young gland; *a*, *b*, *c*, *d*, *e*, *f*, *g*, developing gland; *p*, protoplasm in trichome; *k*, crystals.

Powder.—This is a dirty, brownish-green, and when moistened and pressed is sticky. It contains a large number of histological elements, inasmuch as stem, leaf, flower, and seed constituents enter into the powder. The main histological features are hairs, glands, pollen grains, crystals, resin, parenchyma, epidermis, fibres, vessels, and stone cells from the seed. The hairs alone are diagnostic of the powder. There are two or three

types which are prominent, though the hairs make a series of almost every grade from the long, thin falciform to the short, stout thorn-like hair: (1) Long, thin, irregular, unicellular, simple, glandular hairs, with spiny

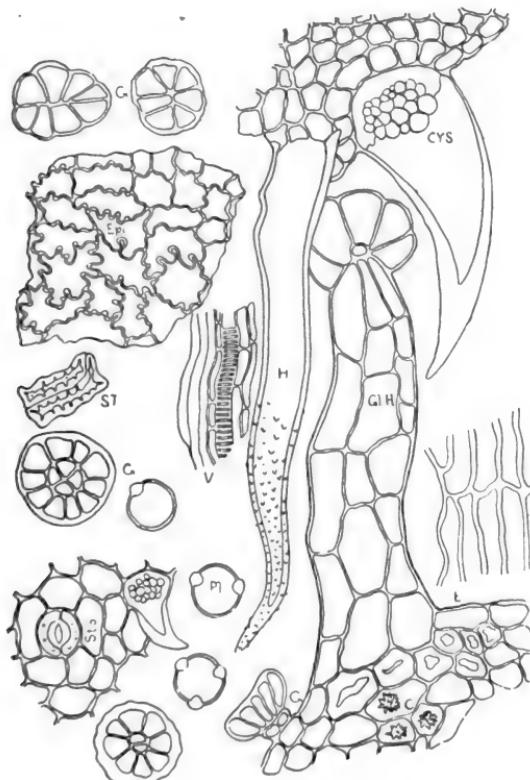


FIG. 61.—POWDERED CANNABIS INDICA.

G, Glands; H, hairs; GI H, glandular hairs; Epi, epidermis; V, vessels; ST, stone cell; Sto, stomata; CYS, crystal sac; Pl, pollen grains; E, epidermis cells; C, crystals.

or wart-like irregular markings found at their apices; these come from the under leaf surfaces; (2) broad, multicellular, simple, glandular hairs with a sub-spherical multicellular gland (usually 8 cells) at the apex; these are numerous and come from the under side of the leaf,

the upper part of stem, and the flower axis; (3) shorter, broad, falciform hairs, with rounded mass-like collections of calcium carbonate at the base of the hair; these are the cystoliths, and occur on the upper leaf surface. The glands proper are rounded and multicellular, sac-like in general shape, and form a conspicuous feature in a good powder. In size they range from 20 to 60 microns. They may be stalked or sessile. Pollen grains are few and may readily be overlooked. They are spherical and regularly marked. Crystals of calcium oxalate of the rosette-shaped variety are also few and inconspicuous. These average about 20 microns in diameter. The parenchyma is thin-walled and lax, and the cells often appressed and gummed together by the resin masses which show as brown and blackish bodies throughout the powder. These irregular masses form a very conspicuous part of the powder. The resin masses and hairs are sufficient for making a diagnosis of the powder.

Epidermal cells with stomata are occasionally found. The fibres and vessel elements vary widely in quantity. In some powders fibres are common, and also spiral, annular, and reticulated ducts; in others these elements are fewer. This depends upon the amount and the development of the stem, which may be included. The seeds show stone cells and small, irregular, twisted, and contorted epidermal cells. These are diagnostic of themselves. Attached to these seed elements are cells containing small masses of starch grains and sometimes masses of aleurone grains.

Chemistry.—Indian hemp contains about 20 per cent. resin. A brown, alcoholic extract obtained from this is known as cannabin, and from this oxycannabin has been isolated. The alkaloid cannabinine also occurs.

FRUITS.

Fruits cannot be said to have any particular type of structure. In the main, the official fruits consist of parenchymatic tissues arranged in different ways, according to the individual plant under consideration. In addition to this, some vascular elements may be encountered and also some sclerotic cells.

CARYOPHYLLUS. CLOVES.

Caryophyllus, cloves, is the unexpanded flowers of *Eugenia aromatica* (*Eugenia caryophyllata*, Thunb.), a handsome and large evergreen, cultivated in the islands of the Indian Ocean, Sumatra, Penang, in southern India, Africa, the West Indies, South America, and in other tropical regions.

The cloves of commerce come in large part from the east coast of Africa, and the chief mart is Rotterdam.

Wild trees contribute but a small proportion of the entire yield. The cloves are gathered from trees which are from six to twelve years old, and after the trees are twenty years old they do not bear well. One tree frequently yields from two to four kilos of fruit (Flückiger). The cloves are gathered just before the corolla of the flower falls off, either by hand or the trees are beaten with sticks and the falling cloves collected on spread-out cloths.

After drying, the clove becomes characteristically dark-brown and has its own peculiar aroma. Its fracture is short and sharp to waxy.

Histology.—A section of the solid, stem-like lower portion of the clove, technically the hypnanthium, shows the disposition of the tissues as follows: An outer dark-

brown zone surrounds a lighter brown central zone. Sections in the upper portion, just beneath the spreading of the calyx lobes, cut into the ovary with its two carpels and numerous ovules (about twenty) arranged on a central placenta. The minute anatomy of the cross-section shows greatly thickened outside epidermic cells, 13 to 15 microns in diameter; as Tschirch has pointed out, this is

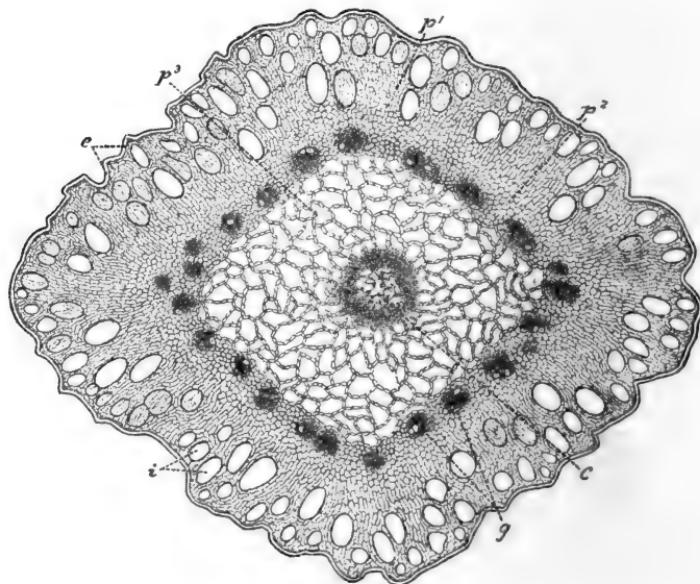


FIG. 62.—CLOVE.

Cross-section of base of clove: *e*, Epidermis; *p*¹, parenchyma with oil canals; (*p*¹)—*p*², parenchyma with interspersed vessel bundles; *p*³, loose parenchyma; *c*, columella; *g*, vessels; *i*, oil cells (Wiesner).

not strongly cutinized. Beneath this single epidermal row there are numerous thin-walled parenchymatic cells. These are radially elongated, and surround numerous schizogenous oil glands, which are arranged in from two to three rows. The parenchymatic cells measure from 15 to 30 microns. The oil glands are oval elliptical, surrounded by two or three rows of flattened secreting cells, and measure from 170 to 220 microns in the radial diam-

eter and 30 to 125 microns tangentially. Those nearer the epidermis are usually smaller. The parenchymatic tissue lying within the area of the oil glands is larger, the cell walls are more pronounced, and collenchymatic thickening is more common, though it is not absent, for the outer parenchymatic rows. Fibro-vascular bundles are found here and the tissues become lax, and large intercellular spaces are prominent. The bundles are delicate, more or less incomplete, contain small vessels and fibres, and are, in general, of the open collateral type; bi-collateral, and bundles concentric to a central sieve portion and peripheral to an outer sieve portion, are described by Tschirch and Oesterle. Bast fibres are found on the outer portions of the bundle. They average 40 to 50 microns in diameter. Closely surrounding the bast fibres, usually lying between them and the vessels, small crystal cells are closely clustered. A well-marked columella is found in the centre of the section. It is connected with the outer portions by the loose, parenchymatic tissue with large intercellular spaces. The columella contains incomplete fibro-vascular bundles. The vessels and fibres are usually very delicate. Numerous small crystals are here present. Sections of the calyx lobes show numerous oil cells, with typical leaf structures.

If sections of the hypnanthium, after previous soaking in water, are placed in a low flat dish in alcohol, or a micro-slide-cell, crystalline needles of caryophyllin develop. Similar sections placed in official potash solution, and then soaked in water in a cell, show in from one to two hours, the development of fine crystal needles of eugenol potassium, $C_6H_5(C_3H_5)OCH_3OK$. These are particularly abundant in the oil reservoirs.

Powder.—The powder of cloves is composed of a great many diverse elements, and its complete study is attended with much patient effort. The powder is dark-brown. It contains parenchymatic tissues, collenchyma, bast

fibres, wood fibres, spiral and annular ducts, tracheids, crystals, epidermis of calyx lobes with stomata, tissue from corolla, pollen grains, tissues of the seed, and if

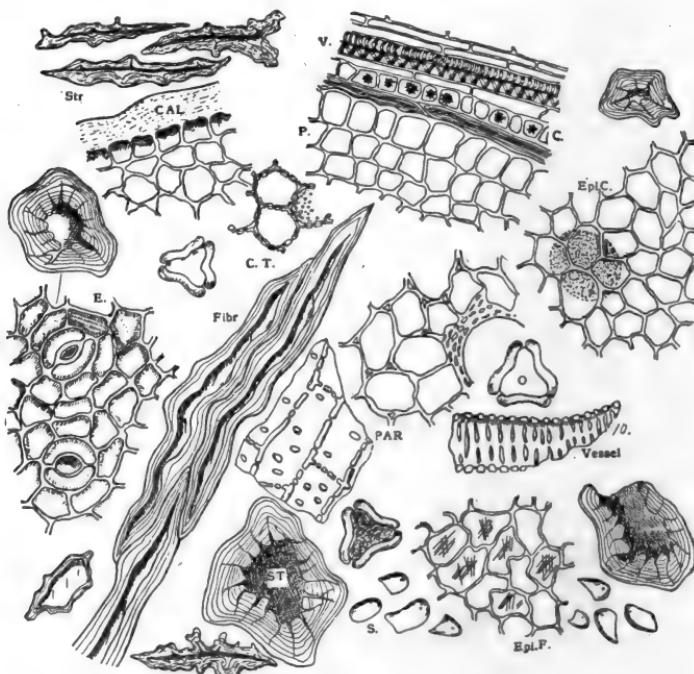


FIG. 63.—CLOVES IN POWDER.

Epi.C, Epidermis of calyx showing oil glands beneath; Epi.F, epidermis of corolla; E, epidermis of outer side of calyx teeth, with stomata; CAL, cross-section of calyx (Epi.C), outer cuticularized wall and collenchymatic tissue; P, parenchyma of body of cloves with fibres, V vessels, and C crystals; PAR, parenchyma of fruit body in cross-section, to right, and longitudinal section, to left, the latter showing pitted parenchyma; ST, stone cells from the stem of the cloves; Str, sclereids from the wall of the fruit; O, pollen grains; Fibr, fibres from the clove stem; Vessel from the clove stem; C.T, pitted parenchyma from cotyledons; S, starch grains from seed.

much stem has been included, the characteristic sclereids and bast fibres of this part of the fruit are in evidence.

Bast fibres are conspicuous features in the powder; when unbroken, they measure from 300 to 400 microns

long and from 40 to 50 microns in diameter. The degree of signification varies widely.

The pollen grains are characteristic. They are tetrahedral, and may be empty or may contain brownish, oil-stained, protoplasmic contents. They measure about 15 microns to a side.

The vessels are very delicate, and rarely measure more than 4 to 10 to 15 microns in diameter. They have spiral or annular markings, and may be accompanied by delicate tracheids, measuring about the same in diameter.

Epidermis cells with stomata do not call for special mention, as these latter are not of any diagnostic significance. The crystals are small and may readily be overlooked. They measure from 8 to 16 microns. Tissues derived from the petals may be readily recognized by the regular irregularity so characteristic of this type of tissue. In the seed, pitted parenchymatic cells measuring 50 to 70 microns are found. These contain irregular shaped starch grains. These are usually simple grains, but are often much compressed and elongated. Some of the larger grains measure from 30 to 35 microns, while the smaller ones average 5 to 7 microns.

If the powder contains much tissue from the stem the numerous isodiametric sclereids (100 to 130 microns) are found, though similar sclereids are also present to some extent in the walls of the fruit. Larger pitted vessels also are indicative of admixture with stem, and the irregular bast fibres are characteristic. Many of these have knob-like ends, and frequently average, according to the measurements of Tschirch and Oesterle, 8 to 26 microns in diameter. In addition to the rosette crystals, cubical crystals 7×7 microns may be found.

A further chemical reaction is noteworthy in addition to those already described. Solutions of chloride of iron stain most of the tissues dark-blue to black, due, it is said, to the saturation of such tissues with eugenol.

Chemistry.—Cloves contain an ethereal oil, consisting of hydrocarbon and eugenol; some eugenin, caryophyllin, and vegetable mucus.

CUBEBA. CUBEBS.

Cubebs is the unripe fruit of *Piper cubeba*, a plant now extensively cultivated in the Eastern countries, notably Java, Sumatra, Borneo, and the Antilles; though originally it was indigenous to these places and even now is found there growing wild. It is widely cultivated about the coffee plantations, growing on or about the trees which are planted in these places to protect the coffee plants. The fruit is collected before ripening and is handled mainly by the Chinese.

Description.—The cubebs of the market are spherical, dark-brown, grayish-brown and black, and measure about one-fifth of an inch in diameter (5 mm.). They are usually provided with stems about the same length as the fruit or somewhat longer. The surface is hard and irregularly netted or reticulated. At the summit there are the small, lighter colored, pointed remnants of the pistil. The base is contracted to meet the remnant of the stalk, which is anatomically continuous with the outer layers of the pericarp.

Histology.—With a lens the cross-section shows a brownish outer pericarp making up about one-third of the radius of the fruit. The large perisperm makes up the rest of the section. The endosperm is small, and is located at the upper end of the seed, just beneath the remnant of the pistil, and contains the embryo.

Under higher magnification the pericarp is seen to be made up of at least three more or less distinct zones. The epidermis consists of regular quadratic cells, with thickened outer walls, resting directly upon a layer of stone cells, which may be in one or two rows. This layer of stone cells may be broken here and there. The

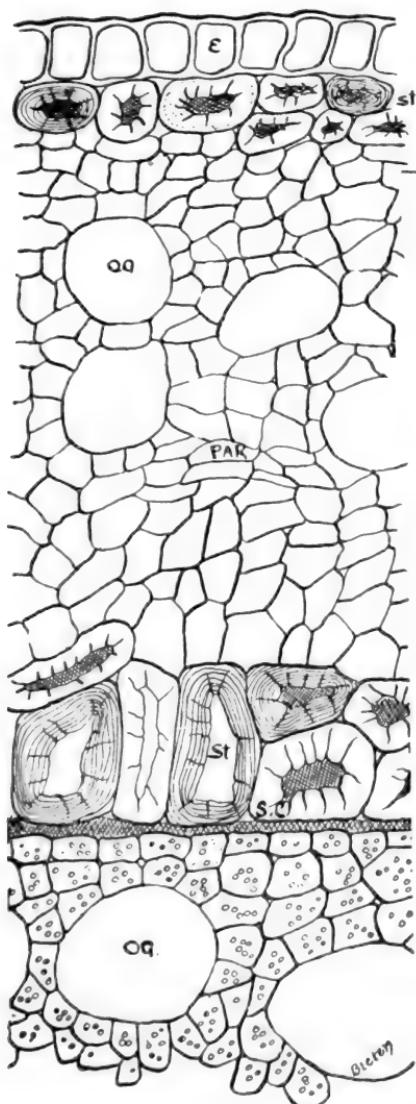


FIG. 64.—CUBEBS, CROSS-SECTION OF FRUIT.

E, Epidermis; St, stone cells, beneath epidermis, hypodermis and at base of outer portion of the fruit; PAR, parenchymatic tissue filled with starch, and oil cells; OG, oil glands; SC, the seed coat inside of which is the seed, with oil cells and starch grains.

walls are markedly thickened and many pored. The parenchyma of the pericarp makes up the greater mass of this structure; it is very irregular, thin-walled, and the cells inclined to be elongated parallel to the surface of the fruit. These cells contain starch and have a number of large oil glands, which have distinctly suberized walls. Oil, fat, and crystals of cubebin may also be found in this parenchyma.

The fibro-vascular bundles run up in the stem and spread out in this parenchymatic layer. They soon become fragmentary, however. The inner zone of the pericarp is made up of very large stone cells, cells from five to ten times the size of the stone cells lying just beneath the epidermis. These are usually arranged with their longest axis at right angles to the thin seed coat, which is just beneath. This seed coat consists of one to two layers of compressed cells, the outer row of which may have a slightly thickened wall. The seed coat cells are dark-brown. Inside of the seed coat the cells of the perisperm are large, thin-walled, starch-filled, parenchymatic cells. The starch grains are very small and compound. The perisperm also contains large oil cells. The starch grains develop as the fruit grows older. Hence specimens according to their age will contain more or less starch. The unripe seed should contain no well-formed grains. Needle-like crystals, occurring in groups, are often observed both in the pericarp and in the perisperm. By some writers these are termed crystals of cubebin. Meyer believes them to be either fatty crystals or a terpene hydrate.

Powder.—Powdered cubeb (No. 50) is grayish-brown in color. The most prominent features of the powder are stone cells, oil globules, starch grains in the ripe fruit, crystalline masses, and parenchyma. Less conspicuous are epidermal structures and fibro-vascular elements.

The stone cells present a variety of shapes and sizes.

Those of the inner row, *i. e.*, just outside of the seed coat, are the largest. These are usually oblong, sometimes three times as long as broad, and measure in the longest diameter from 50 to 75 microns. The smaller stone cells of the hypodermis average 25 to 35 microns. All of the

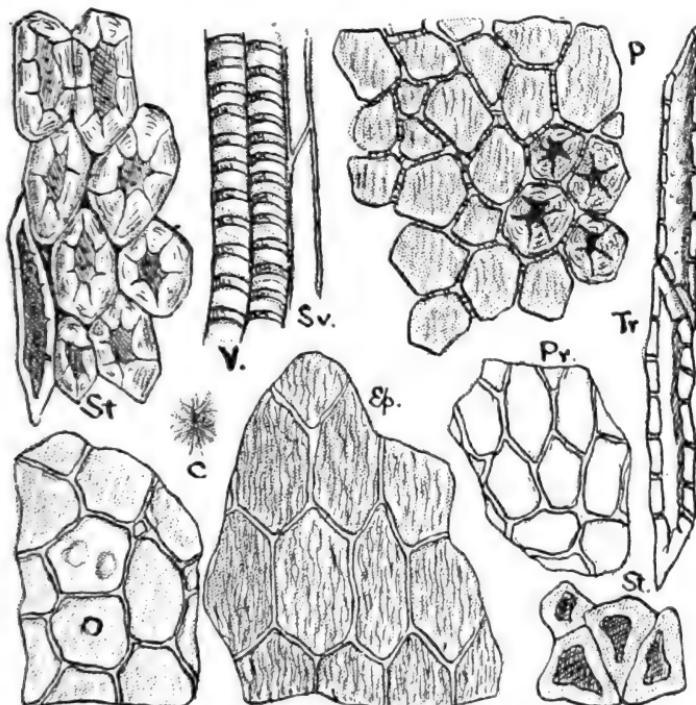


FIG. 65.—CUBEBS IN POWDER.

Ep, Epidermis from upper surface; St. stone cells of the pericarp; P, parenchyma of pericarp with stone cells; Tr, tracheid-like stone cells of the stems; V and Sv, vessel of pericarp and of the stem; O, parenchyma with oil cells and oil globules; Pr, parenchyma of the seed; C, crystal-like bodies of fat or cubebin.

stone cells are richly pored and many are brownish in color. The oil globules are very numerous throughout the entire powder. They are usually lying free, though occasionally not disturbed from the glands, which average 75 to 120 microns in diameter.

The starch grains are found, well formed, only in the

ripe fruit. They are very minute, averaging 1 to 5 microns, and are simple and compound in twos, threes, and fours. The crystal masses are very distinctive; they vary greatly in size and are sometimes very common in the powder, at other times not. Specimens mounted in glycerine jelly will not be preserved, if the jelly in preparation is heated above 125° C. The parenchyma is usually thin-walled and very irregular; in the region of the pericarp many of the cells are pitted and the walls are thicker, the cells being somewhat smaller, 30 to 40 microns. The cells of the endosperm are thinner-walled, average about 40 microns, and are not pored. Epidermal structures are distinctive though not prominent. The thickened walls, which are finely striated, are readily recognized.

The fibro-vascular elements are not numerous, yet almost always present in any small field. Spiral vessels, tracheids, tracheid-like stone cells, and short fibres are constant and some sieve tube elements may be found. The greater the quantity of stems, the more vascular and fibrous elements are found.

Chemistry.—Fresh cubeb contain about 10 to 16 per cent. of ethereal oil, which is contained for the most part in the glands. This oil consists in the main of various terpenes, with the general formula $C_{15}H_{24}$. Cubebin, $C_{10}H_{10}O_3$, is found in amounts varying from 1 to 2.5 or 3 per cent. It is a slightly bitter, colorless, and odorless crystalline body, colored red by concentrated sulphuric acid. It crystallizes in white needles, which have a melting-point about 125° C. Cubebin is usually mixed with the resin, which is found in percentages of about 5 to 7. There is, further, about 8 per cent. of gum and 1 per cent. of fatty oil.

PIPER. PEPPER.

The unripe fruit of *Piper nigrum*, Linné (nat. ord. *Piperaceæ*), a native of India and Cochin-China, cultivated in the East Indies.

Description.—Globular, diameter 4 mm., reticulately wrinkled, brownish-black or grayish-black, internally lighter, hollow, with an undeveloped embryo; odor aromatic; taste pungently spicy.

Histology.—The fruit shows on cross-section a soft,

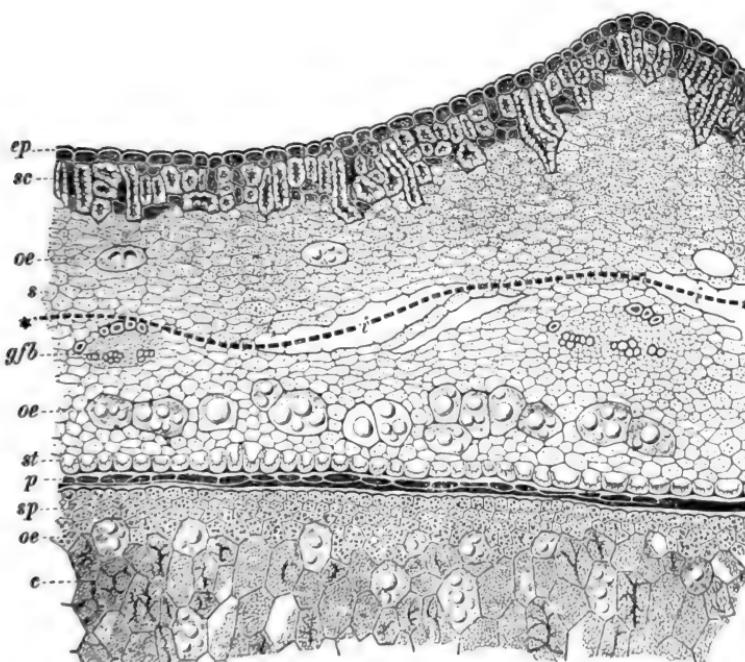


FIG. 66.—PIPER.

Cross-section of outer portion of black pepper: *ep*, Epidermis; *sc*, outer layer of stone cells; *oe*, oil glands in parenchyma, *s*; *st*, inner layer of stone cells; *p*, pigment layer; *sp*, aleurone grains in parenchyma; *g/b*, fibro-vascular bundles; *c*, starch-filled parenchyma of perisperm (Tschirch).

yellowish outer skin, and beneath this a thick, compact layer of large, yellow, thick-walled porous stone cells, mostly radially arranged, which contain in their small cavities small lumps of dark-brown resin. The middle layer of the fruit consists of soft tangentially arranged

parenchyma, which contains many aggregations of starch grains and oil drops.

By the drying of this loose middle layer the berries acquire the marked wrinkling of their surfaces. The tissue next within contains soft prosenchyma and small spiral vessels, and within this, starch-free parenchyma with large oil cells. The seed coat consists of a row of small, yellow cells, on the inner walls of which there is deposited a thickened porous layer; frequently there are therein crystal rosettes of calcium oxalate. The following dark brown-red thick tissue separates the layer from the seed albumen, between which angular radially-arranged cells, numerous oil spaces are disseminated. The first are filled with trophoplasts in which there are numerous small, angular starch grains, with few thick nuclei. Other cells contain yellow grains of piperin; the endosperm contains aleurone grains.

CONIUM. HEMLOCK.

"The full-grown fruit of *Conium maculatum*, Linné (nat. ord. *Umbelliferae*), gathered while yet green." U. S.

Though the fruit alone is official, we shall here consider the leaves also.

The biennial root of the conium plant bears an annual stem, often over 2 m. high, round grooved, hollow, and marked below with brownish-red spots. The plant grows in waste places throughout the old world. It has been naturalized in America. The plant grown in a hot, dry climate is superior.

Description.—The leaves are twice or thrice pinnatifid compound, four to eight-paired, in general outline triangular, the lower ones often 40 cm. long, with sheathing petioles, the upper smaller, almost sessile, and less compound. The leaflets are deeply cleft, prominently veined, the terminal leaflet larger, strongly

toothed. Color, when dry, grayish-green. Odor disagreeable (mousey). Taste salty, bitter, and acrid.

The fruit is a cremocarp, about 3 mm. long, broadly ovate, laterally compressed, the mericarps usually separate, slightly curved, dorsally compressed, bearing five slightly wavy ridges; intermediate spaces wrinkled, faces grooved, oil tubes absent. Color gray or green, odor and taste faint. The disagreeable mousey odor is developed by trituration.

Histology.—The Leaf.—A single layer of smooth polyg-

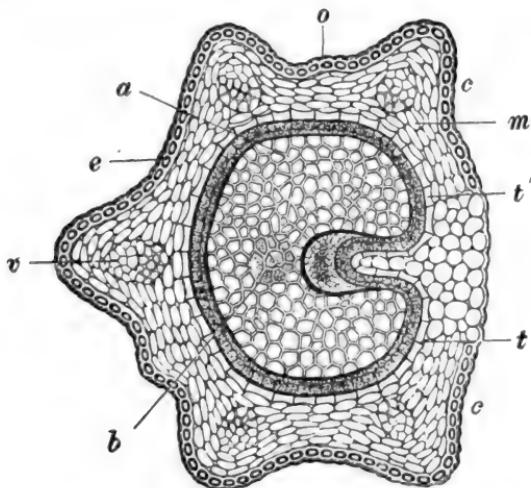


FIG. 67.—CONIUM.

Cross-section of mericarp of *Conium*: *a*, Seed portion; *e*, epidermis; *m*, fruit scale; *t*, *t'*, conine layer containing alkaloid; *v*, vascular bundle; *o*, outer surface of pericarp; *c*, central surface; *b*, bundle in albumen (Flückiger).

onal cells forms the epidermis. The outer walls of these epidermal cells are thickened. A single row of palisade cells is found. Beneath these, and extending to the under epidermis, is the usual loose round-celled leaf parenchyma. The veins each contain a single fibro-vascular bundle, accompanied by a few resin ducts, and protected by the collenchymatic tissue, to which the

prominence of the vein is due. Stomata are numerous, particularly on the lower surface. Many cells of the epidermis contain groups of crystals, said to be hesperidin.

The Fruit.—The epidermis of the mericarp is composed of irregularly thickened and finely striated cells, with occasional stomata. Within this layer lies the mesophyll of thin-walled, compressed polygonal cells, which in the unripe fruit contain starch and chlorophyll. In each rib is a fibro-vascular bundle. These consist of a central bast bundle, with, on either side, a smaller sieve bundle, and on the inner side of the whole a group of vessels. The bast fibres are of the usual type. The vessels are mostly spirally marked. Near each bundle, on the outer side, lies a small resin duct. Surrounding the seed are two very characteristic cell-layers, the outer of large tangentially elongated cells with dark-colored walls, much thickened on the inner and lateral faces. The layer within, the endocarp, is formed of cubical or slightly radially elongated cells whose brown walls are somewhat thickened on the inner and outer faces, while remaining quite thin on the sides. It is this endocarp which contains the active principle of the drug. Within the endocarp is a seed-coat of small, thick-walled cells surrounding the polygonal cells of the albumen which are filled with aleurone grains and fat. The aleurone grains are mostly 5 to 6 microns in breadth. They often contain one or more round or irregularly swollen masses or single or agglomerated crystals of calcium oxalate. (Tschirch and Oesterle.)

The absence of oil tubes serves to distinguish this fruit from all others of the *Umbelliferæ*.

Chemistry.—The fruit contains four alkaloids,—conine, methyl conine, conhydrine, and pseudoconine,—a little volatile oil of a conium-like odor, fat, and 6 per cent. of ash.

The herb contains traces of the alkaloids, a little volatile oil, and about 12.8 per cent. of ash.

Conine is a volatile, non-oxygenated, highly poisonous alkaloid of a strong, disagreeable odor and an acrid and bitter taste. It is an oily liquid, specific gravity 0.88, boiling at 167°C., soluble in alcohol, ether, and 90 parts of cold water. It fumes in contact with hydrochloric acid and forms soluble crystalline salts with this and other acids. Methylconine is a similar oily liquid, boiling between 169°C. and 180°C. Conhydrine, 0.006 per cent. present in the herb, crystallizes in colorless, pearly plates which sublime below 100°C., and treated with phosphoric anhydride yield a β and γ coniceine. Pseudoconine crystallizes in needles, melting at 98° C.

Fœniculum. Fennel.

"The fruit of *Fœniculum capillaceum*, Gilibert (nat. ord. *Umbelliferæ*)."
U. S.

A perennial herb, 1 to 2 m. high, with decompound leaves, growing throughout Europe and Asia, more plentifully in the warmer regions. It is cultivated in France and Germany.

There are two principal varieties, Roman and German. Indian fennel and bitter fennel are of less frequent occurrence.

Description.—German or Saxon fennel. The fruit is from 5 to 8 mm. long, straight or slightly curved, and about 3 m. in thickness, almost cylindrical, with five distinct greenish-yellow ribs on each mericarp, the lateral ones being more strongly developed than the others. Two short, thick styles surmount the fruit. The color in general is greenish-brown, the taste sweet and camphoraceous.

Roman or Italian fennel differs from the above in its greater length, 10 to 14 mm. This dimension, however, varies with the age of the plant, each succeeding year

producing a smaller fruit. Its taste, though quite aromatic, is less sharp than the German fennel.

Histology.—The epicarp of the half fruit, which is less smooth, is formed of tabular cells with walls slightly but evenly thickened on all sides. Viewed on the sur-

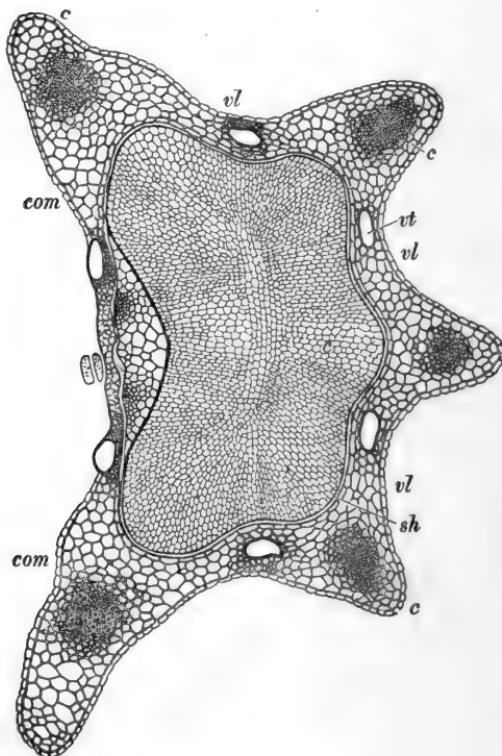


FIG. 68.—FENNEL.

Cross-section of mericarp of fennel: *com*, Commissural side; *c*, ribs with small vessel bundles; *vt*, vittæ, and *vl*, valleculæ, oil passages; *c* (in center), endosperm of seed; *sh*, endocarp sheath (Tschirch).

face, they are irregular in outline, somewhat angular, with sparsely distributed oval or almost round stomata. Imbedded in the mesocarp of the usual thin-walled tissue are the oil tubes, six in number, two on the inner face, the other four in the outer intercostal spaces. The

cells forming the surface of the oil tubes are sharply angular in outline, and, with the surrounding tissue, of a dark brown color, caused by the infiltration of the resinous contents of the oil tubes. The fibro-vascular bundles, one in each rib, are composed of spiral and reticulate ducts, 4 to 6 microns broad, small, 2 to 3 microns broad, much pitted tracheids, and, making up the greater portion of the bundle, bast fibres which merge gradually into the characteristically large-pored parenchyma surrounding the bundle. The endocarp is also distinctly characteristic, made up of a single layer of narrow, oblong, thin, straight-walled cells, in groups which are arranged at various angles to each other, but composed individually of regularly parallel cells.

Powder.—The brown angular oil tube cells and surrounding tissues form the most conspicuous elements of the powder. They are of no diagnostic value, but by clearing with chloral hydrate and treating with Schultze's maceration fluid, the characteristic tissues may be found. These are the large-pored parenchyma cells, surrounding the vascular bundles and the oblong cells of the endocarp. By treating with oil the cells of the endosperm are seen to contain numerous single aleurone grains, in which are found calcium oxalate crystals in angular masses. (Tschirch and Oesterle.)

Chemistry.—The essential constituent is the volatile oil. This varies greatly in the several varieties of the drug, both in quantity and composition. It has a specific gravity of 0.90 to 0.99, is soluble in all proportions of alcohol, becomes crystalline at low temperatures, 5° to 10° C., owing to the separation of anethol, pinene, dipentine, fenchone, and phellandrene. The percentage of anethol varies greatly. The oil of the Italian or sweet fennel, esteemed for its mild flavor, probably owes this quality to a lower proportion of anethol. (Flückiger.)

SEEDS.

Seeds possess few universal characters. In general the tissues to be distinguished microscopically are the cells of the seed coat, or testa; those of the nucleus of the young plant, and those of the cotyledons. The seed coat differs greatly in the different seeds. In general, however, it is composed of parenchymatic cells with greatly thickened cell walls. The thickness of the cell walls differs in every seed, but most of the seeds of the Pharmacopoeia have stone cells in the seed coat. The tissues of the cotyledons are usually thin-walled and parenchymatic. Occasionally very delicate spiral vessels may be found in the cotyledons. Aleurone grains and starch grains are important features in seed structures. One or the other, and frequently both, are found in seeds.

AMYGDALUS DULCIS. SWEET ALMOND.

The seed of *Amygdalus communis*, L., a plant originally found in Asia about the region of the Caspian Sea, now quite widely spread by cultivation in the milder climates of the world. Southern Italy, Spain and Greece, and the northern countries of Africa are the regions more commercially active.

Description.—Elongated, thin; average size 2.5 cm. long and 1 cm. broad, 0.5 cm. thick.

Commonly two forms are found, those with the hard shell and the paper-shelled. In the hard shell the outer pericarp wall is thick and plentifully provided with stone cells. In the paper-shelled this outer pericarp layer is more fibrous and thinner. The inner walls of the shell are alike in the two; hard, made up of compact smooth layers of stone cells; between the two layers a more or less coky tissue is to be found, thickly interwoven with fibro-vascular bundles. Some stone cells may be found interspersed.

The almond itself consists of two cotyledons closely appressed, surrounded by a thin brown layer of parenchymatic tissue, with numerous fine vessel bundles ramifying over the surface; this layer is readily removed by soaking the seed.

Histology.—The outer layer of cells, the endocarp, consists of a number of layers, the outer ones of which are brown, flattened. These are often irregular because of the fine vessels that pass into the tissue of the endocarp. Calcium oxalate crystal sacs are also found.

The inner layers are made up of small colorless cells whose outer walls are somewhat swollen and form a sort of interlacing with the inner cells of the exocarp. The inner face of the endocarp is united but slightly with the cells of the cotyledons.

The cotyledons consist of numerous parenchymatic cells which are smaller and more regular at the periphery and increase in size and irregularity toward the centre. The cells contain numerous oil globules and also aleurone grains. Starch is lacking.

Chemistry.—Over one-half the weight of the seed consists of a clear yellowish oil, mild tasting, sp. gr. 0.920° . It consists for the main part of the glycerine ether of oleic acid, $C_{80}H_{34}O_2$, also probably a number of the fatty acids found in *Linum*. A small amount of sugar (glucose) is also found. This with mucilaginous materials makes up about 7 per cent.

PHYSOSTIGMA. CALABAR BEAN.

Physostigma is the seed of *Physostigma venenosum* (Balfour), a member of the *Papilionaceæ*. It is a climbing shrub, sometimes 16 m. high, a native of the delta of the Niger and the Guinea Coast. Cultivation has proved successful.

A so-called Calabar Bean comes into European markets

which is closely similar to *Mucuna cylindrosperma*, Welwitsch.*

The seeds, two or three in number, are contained in pods about 18 cm. long.

Description.—Calabar beans are chocolate-colored and

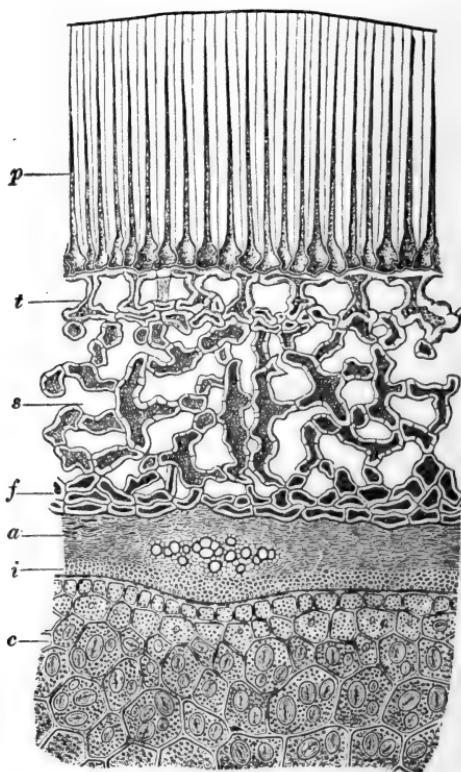


FIG. 69.—PHYSOSTIGMA.

Cross-section of outer portion of physostigma seed: *p*, Palisade cells; *t* (macrosclereids), sclereids of spongy portion; *s*, pigment layer; *f*, microscleireids; *a*, outer seed coat with small vessels; *i*, inner seed coat; *c*, cotyledon (Tschirch).

2.5 cm. long, 2 cm. broad and 1.5 cm. thick. In shape they are oblong-reniform, one side being flat or slightly convex and the other well curved. Along

* Holmes: Ph. Jour., ix, 1879, 913.

nearly the entire length of the curved side, and passing completely around one end of the seed, runs a broad, deep groove, the lips of which are thickened and paler in color and the bottom of which is black and bears a distinct brown furrow in the centre. In this hilum there are frequently portions of a white papery funiculus. At one end the micropyle can be detected as a minute depression.

Histology.—On cross-section near the chalaza four distinct tissues can be made out.

The external layer consists of closely appressed cylindrical cells with small lumen. These are one layer thick and have a palisade arrangement. Externally the ends are square, internally rounded and passing into the second row of tangentially arranged cells. These are more irregular and have thick walls and brownish cell contents. A number of air spaces are found in this layer. The third layer consists of much more irregularly arranged cells. The last layer consists of flattened, dark-brown, tangentially arranged, thin-walled cells, under which the parenchyma of the cotyledons is found. This is made up of large cells, the outer layers being smaller and more regularly arranged. The cells contain large amounts of starch and a number of protein granules. The starch is ample and consists of large, elliptical grains with irregular hilum, and by polarized light shows curved lines similar to those found in papilionaceous starches.

Chemistry.—Taste and smell are similar to those of other members of the bean family. Starch, 40 to 50 per cent.; proteids, 23 per cent.; 3 per cent. ash; mucilage. The most important constituent is the alkaloid physostigmine (eserine). Hesse proposed the formula $C_{15}H_{20}N_3O$.

Harnack and Witowski have isolated a second alkaloid, which they have called calabarine. This, they state, is allied to strychnine. The alkaloids are found in the

cotyledons only. Hesse also found a cholesterin-like substance, physosterin.

NUX VOMICA.

Nux Vomica is the dried seed of *Strychnos Nux Vomica*, L., a small tree, indigenous to India and occurring also in Ceylon, Siam, and northern Australia.

Description.—Dried Nux Vomica seeds are round or disk-shaped, and flattened but a little depressed on one side, and flattened on the other. They vary from 2 to 2.5 cm. in diameter and 0.33 to 0.5 cm. in thickness, and are grayish in color. A number of closely appressed hairs radiate from the centre to the circumference. The edge is rounded or acute and at one point there is a prominence, the micropyle. The hilum is in the centre, and may be recognized by the scar left by the funicle. The seeds are almost odorless, but have an intense bitter taste.

Histology.—A thin epidermis covers the entirely gray endosperm.

The epidermis cells are thick-walled, deeply pored, side walls swollen. Each epidermis cell has a long, free papillose round-pointed hair, 1 mm. long, sharply inclined.

Beneath the epidermis there are a number of large cells with dark-brown walls.

On the outer surface of the endosperm is a layer of small cells whose side walls are perpendicular to the surface. These walls swell but slightly in water. The layers immediately beneath swell markedly on being placed in water.

The layer of cellulose immediately surrounding the lumen is apt to be more highly refractive than the surrounding layers. The membrane of the cells is completely perforated by a few fine punctures. The membranes show the reaction of cellulose. In the interior of the endosperm cells are aleurone grains with crystalloids very

variable in size and quantity and some fatty oils. The cells of the embryo are parenchymatic, have at times a few spiral vessels and cell contents of aleurone grains and fat.

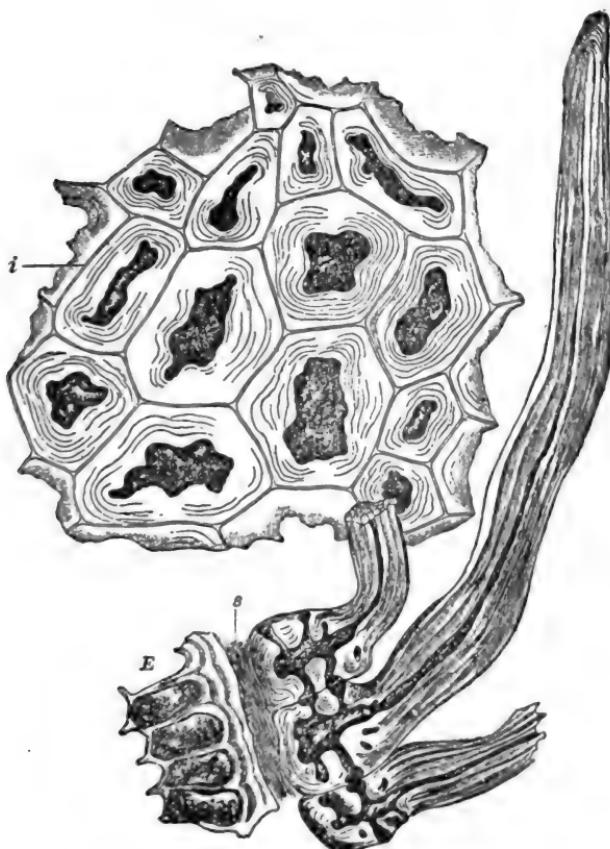


FIG. 70.—SECTION OF *NUX VOMICA* SEED.

Showing *i*, the thick-walled cells of the seed; *E*, the elongated cells beneath the long hairs; *s*, sheath beneath hairs.

Chemistry.—About equal amounts of strychnine and brucine, 0.23 to 5.3 per cent. Loganin, tannic acid, 40 per cent. fat. Palmitin, caprin, and caprons. Butyric acid, alkaloid in the endosperm. Not definitely known

whether to be found in the cell wall or in the protoplasm of endoderm cells. Probably in protoplasm (Mayer). Igasurine probably does not exist.

IGNATIA.

The seeds of *Strychnos Ignatia*, Bergius, a stout climbing plant indigenous to the southern Philippine Islands.

Description.—Dried ignatia beans vary considerably in size, and are of dull grayish color and irregular ovoid outline. In general they are 2.5 cm. long and somewhat less broad and thick. Frequently there is one large, curved side seed and three or four smaller, flatter surfaces, but some seeds are altogether irregular. The hilum is generally readily seen and sometimes there are remnants of the seed-coat covering the horny surface.

Histology.—When soaked in warm water, the large endosperm can be divided into two portions, enclosing between them a cavity in which lies the embryo, with its small radicle and leafy cotyledons. The cells resemble those of *nux vomica*, but hairs are absent.

Chemistry.—The constituents are those of *nux vomica*.

SINAPIS. MUSTARD.

Sinapis is the seed of *Sinapis nigra*, L., a member of the nat. ord. *Cruciferæ*, now cosmopolitan.

Description.—The seeds are small, about 1.5 mm. in diameter, spherical, slightly umbilicated, and of a dark-brown color. Under the magnifying glass the surface is finely reticular.

The powder is green.

Histology.—The epidermis consists of colorless, hexagonal, tubular cells, whose inner walls undergo the mucilaginous modification upon the addition of water. Just beneath this row of cells there is a layer of palisade-like cells whose inner walls are thickened and deeply

colored from about half-way down, the outer walls remaining thin and colorless or light yellow.

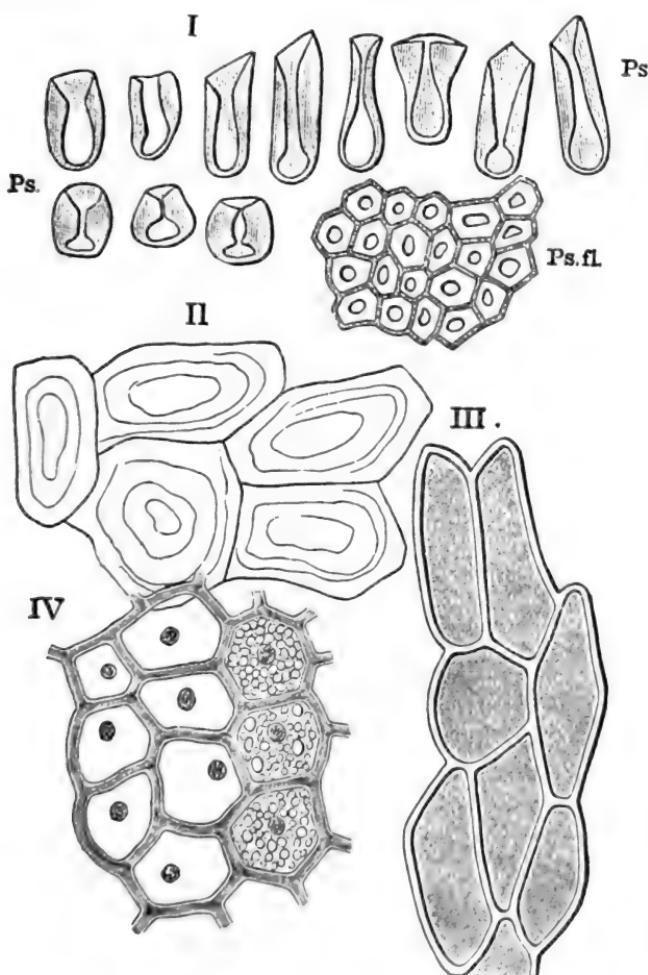


FIG. 71.—BLACK MUSTARD.

I, Stone cells of the walls of the seed, shown sidewise, Ps., and on end, Ps.fl. II, Epidermis cells on surface view. III, Pigment layer. IV, Aleurone layer (Vogl).

Beneath the palisade there follows a single row of tangentially arranged thick-walled cells, colored dark brown.

Beneath this a zone of colorless cells filled with aleurone grains and oil, and finally a many rowed layer of empty compressed cells.

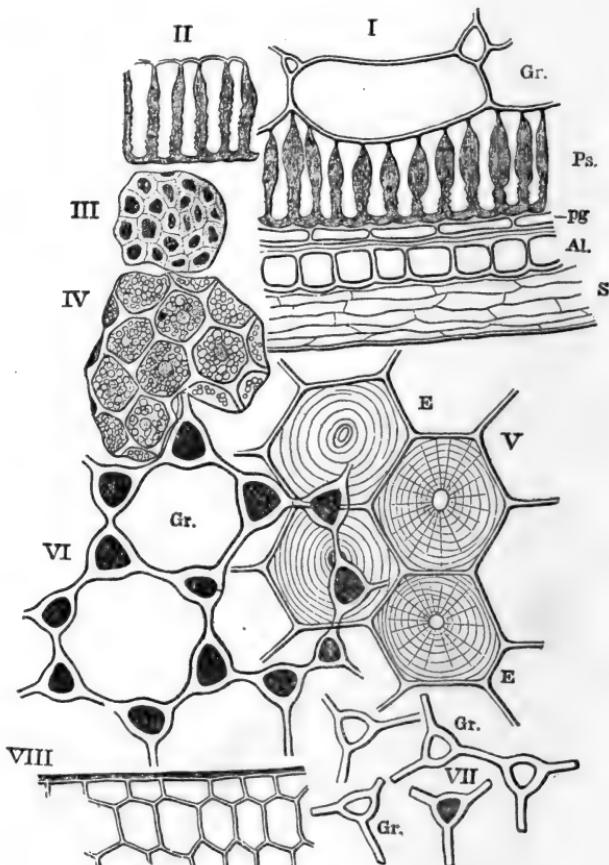


FIG. 72.—WHITE MUSTARD (*SINAPIS ALBA*).

I, Part of testa: Gr, large cells; Ps, palisade cells; pg, pigment layer; Al, aleurone layer; S, hyaline layer. II, Isolated cells of sclereid layer. III, Sclereid layer seen from surface. IV, Aleurone layer. V, Epidermis. VI, Large cells from above. VII, Fragments of large cells in powder. VIII, Tissue from cotyledon (Vogl).

The cotyledons consist of a regular thin-walled parenchymatic tissue whose outer layers are thicker walled and smaller.

The contents are proteid granules and oil globules.

Chemistry.—Mustard contains 33 per cent. fatty oil, about 18 per cent. proteid, 19 per cent. mucilage, and 4 to 6 per cent. ash, a glycoside, sinigrin, and a ferment, myrosin, whose interaction in the presence of water yields the volatile oil of mustard (allyl sulphocyanate).

PEAS AND BEANS.

A knowledge of the structure of the seeds of the pea and the bean is of great service to the student of pharmacognosy, as these two seeds enter so largely into the manufacture of so many products.

The pea is the seed of *Pisum sativum*, L., a universally cultivated plant. Nat. ord. *Leguminosæ*.

Histology.—On the outside of the pea there is a thin epidermis which is palisade-like in structure, the cells being about 10 to 15 microns in diameter and 50 to 60 microns long. The walls are irregularly thickened and are not lignified. The lumens of the epidermal cells are very irregular. They are almost occluded by the thickening of the cell wall in the middle of the cells; below the lumen widens out perceptibly. Beneath the epidermis a row of thin-walled irregularly quadrate cells, the hypodermis, is found. These cells are about 35 microns in diameter, and have a somewhat dumb-bell form. The remainder of the seed is formed of parenchyma largely filled with starch and with aleurone grains. Tissues about the hilum show a slight thickening of the cell walls, forming a double layer of palisade cells, and certain elongated elements resembling tracheids may be found.

The cells of the cotyledon epidermis are isodiametric, contain aleurone grains, while the main body of the cotyledons is made up of large parenchymatic cells,

* Die wichtigsten vegetabilischen Nahrungs und Genussmittel.

COMPARISON OF PEA, BEAN, AND LENTIL.

	PALISADE EPIDERMIS.	HYPODERMIS.	PARENCHYMA OF COTYLEDONS.	STARCH.
Pea . . .	75 to 110 microns long (average 90), not conical toward cuticle; inner cell wall irregular; lumen wide near the inner wall, contracting in centre, and widening externally.	Delicate goblet, beaker or dumb-bell-shaped cells whose inner walls are somewhat thicker than outer; large intercellular spaces between cells at side (radial diameter 30 to 36 microns, transverse 36 to 45 microns), rather thick walls with cleft pores, no crystals.	Moderately thick-walled cells, 3 microns, pitted; cell wall smooth or minutely beaded in cross-section.	15 to 51 microns, irregular in shape, with many protuberances; reniform and bean-shaped forms; few elliptical. Hilum in many absent as fissure; distinctly annulated.
Bean . . .	30 to 60 microns long; not conical at cuticle; wall smooth within; lumen wide at inner side, occluded soon to periphery.	Cross-section four-sided, without intercellular spaces (radial diameter 15 to 30 microns, transverse 15 to 25 microns), thickened at the sides and containing crystals of calcium oxalate (6 microns).	Thick-walled cells with large pores, walls at least 5 microns thick and coarsely beaded in cross-section.	Distinctly elliptical, up to 57 microns; kidney- and bean-shaped with long cleft hilum. Annulations marked.
Lentil . . .	45 microns long, with a short conical projection at cuticle; inner wall smooth; lumen wide, contracting toward outer wall.	Compressed dumb-bell or hourglass-shaped, often irregular, seldom elongated, with intercellular spaces and cleft pores (radial diameter 9 to 24 microns, mostly 15 to 18 microns; transverse diameter 15 to 30 microns), no crystals.	Thin-walled cells which on cross-section are slightly or indistinctly pitted.	9 to 45 microns, resembling both bean and pea grains; many with concentric markings, not as distinct as bean starch; many with small unbranched fissured hilum, others no fissure.

filled with starch grains. The starch grains are very irregular, but are elongated oval, with lacerate elongated hilum. They average 20 to 40 microns in short and long diameters.

The seed of the bean resembles that of the pea very closely, but differs in a few important particulars. The epidermal cells are palisade-like, as in the pea, but the thickening of the cell walls is very characteristic. The entire lumen of the epidermal cells is occluded save at the base, where the walls become thinner. The palisade cells are also shorter (30 by 60 microns). The hypoderm

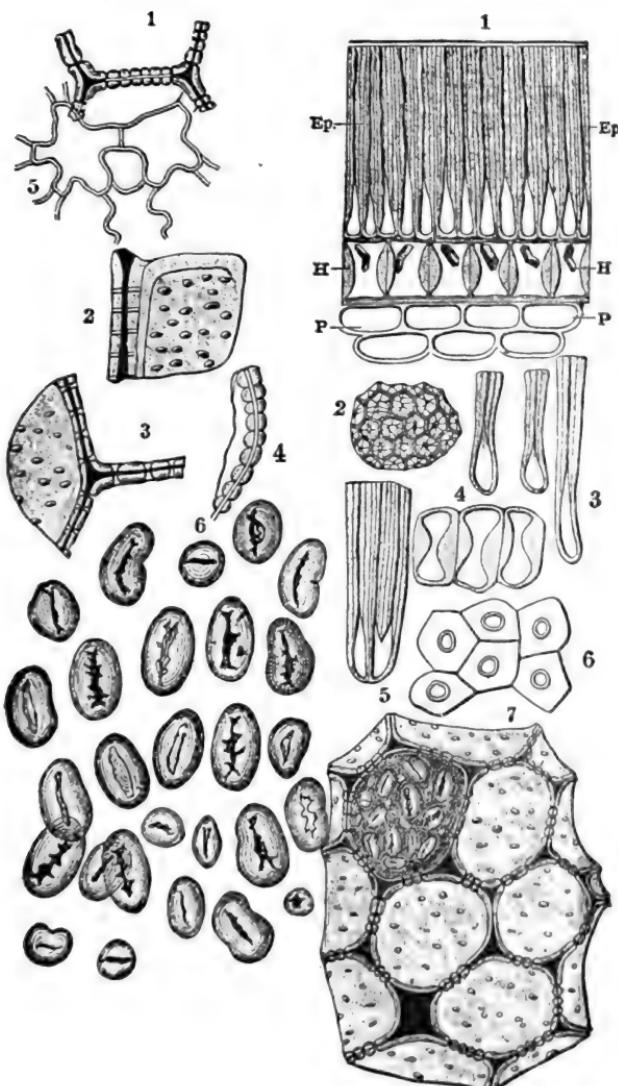


FIG. 73.—BEAN.

On right side of illustration: 1, The testa, showing epidermal cells, Ep; H, hypoderm with calcium oxalate crystals; P, parenchyma; 2, epidermis cells on surface; 3, 5, isolated palisade cells; 4, hypoderm cells in profile; 6, on surface; 7, tissue of cotyledon. On left side: 1-4, Portions of cotyledon structure; 5, tissue of the shell; 6, starch grains (Vogl).

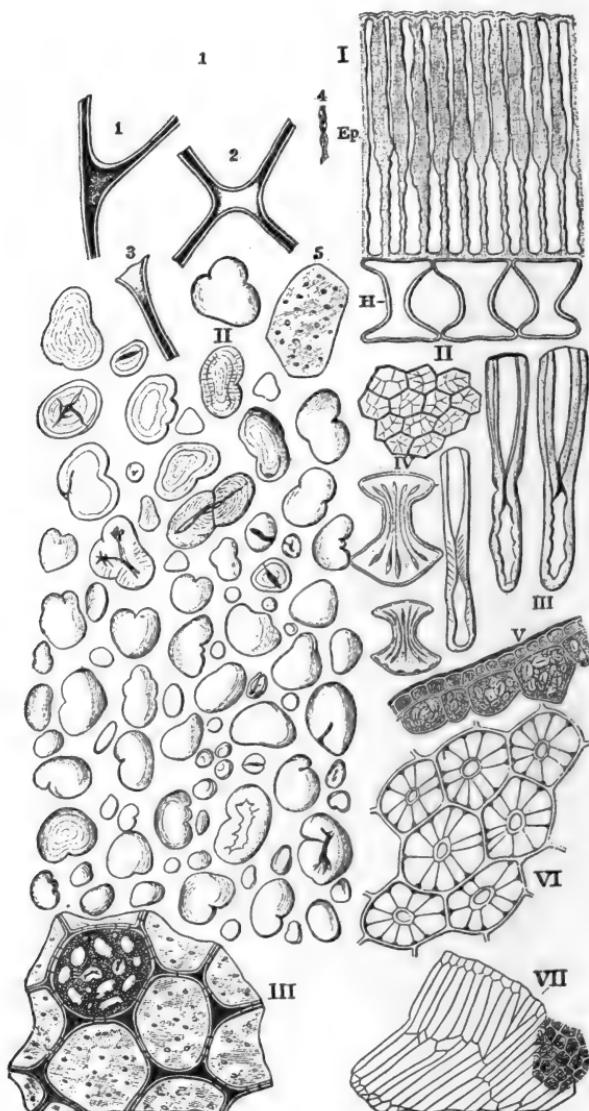
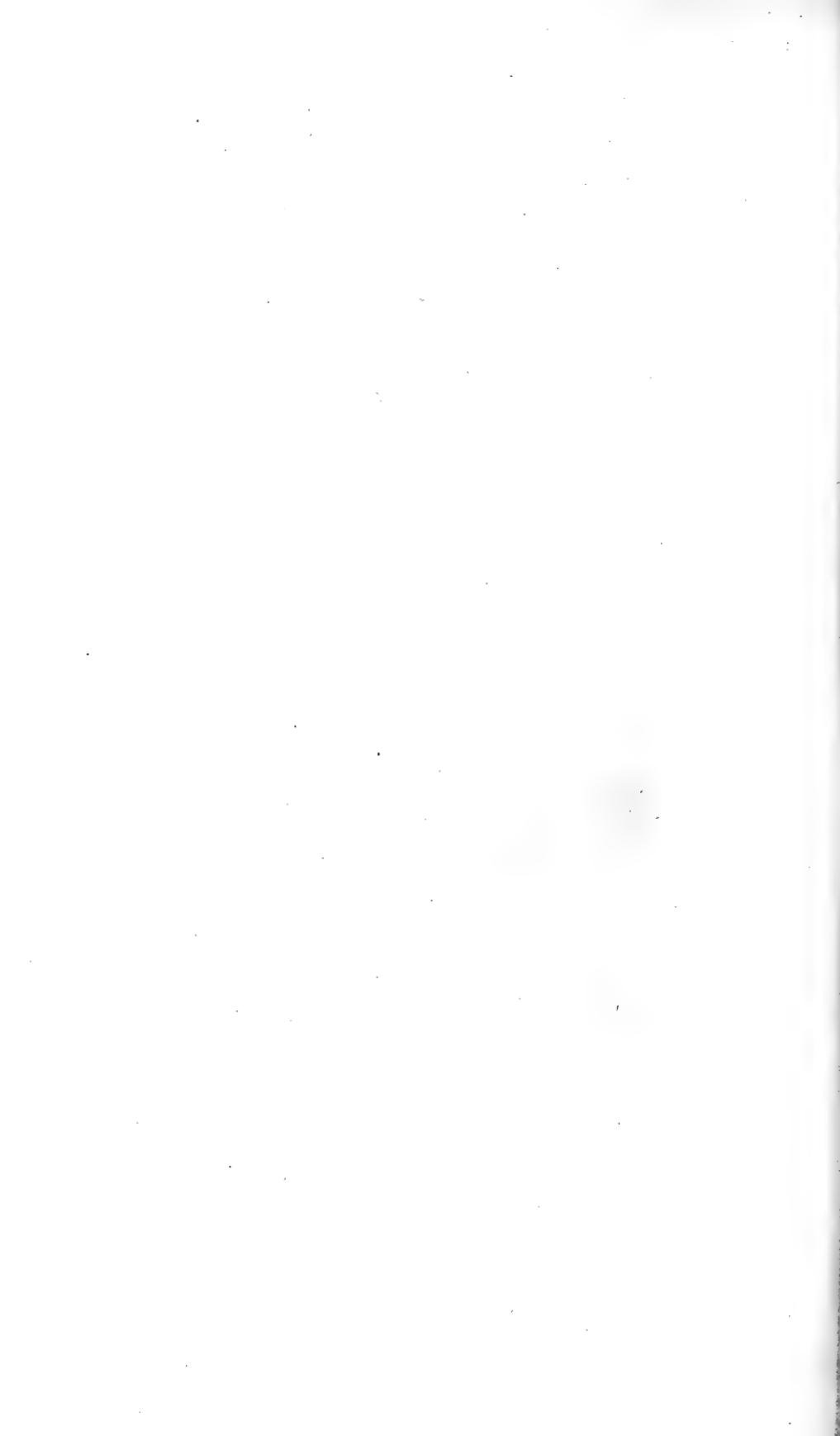


FIG. 74.—PEA.

On right side of illustration: I, Cross-section of testa; Ep, epidermis; H, hypodermis; II, palisade cells on flat; III, isolated palisade cells; IV, hypoderm cells; V, epidermis in cotyledon leaves; VI, hypoderm cells on flat; VII, cotyledon epidermis. On left side: 1-5, Cell fragments of cotyledons; II, starch; III, cotyledon parenchyma (Vogl).

cells are usually smaller, about one-half the size of those of the pea, and the side walls are more markedly thickened. The parenchyma in the centre of the seed of the bean is made up of isodiametric cells whose walls are distinctly thicker than are the walls of the parenchyma of the pea. The starch grains are more distinctly oval and much larger, 50 microns representing the longer diameter of the larger grains. The hilum is distinctly elongated and lacerate.

The table from Vogl* on page 250 shows the contrasts more definitely.



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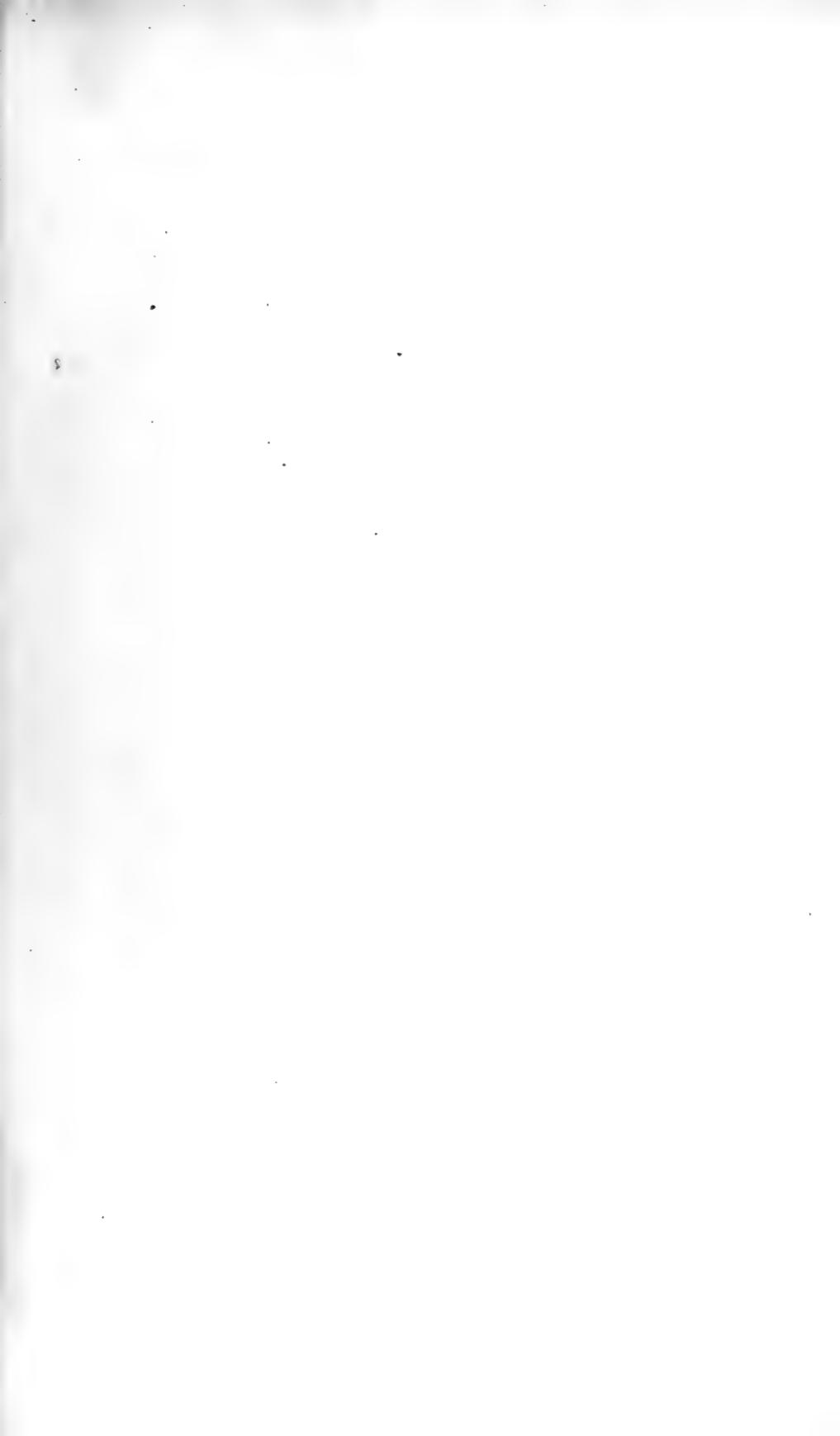
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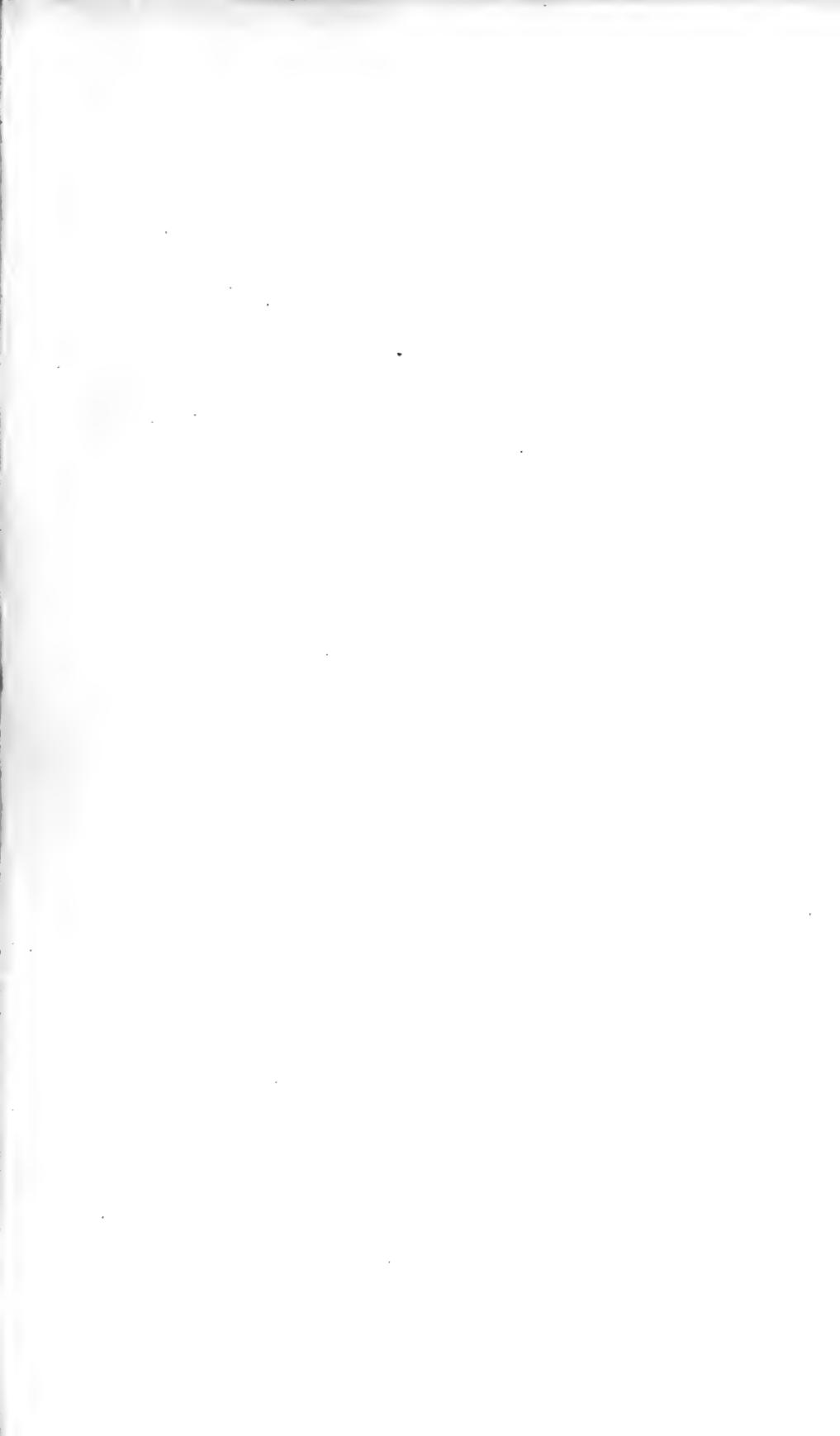
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